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1927—1928.

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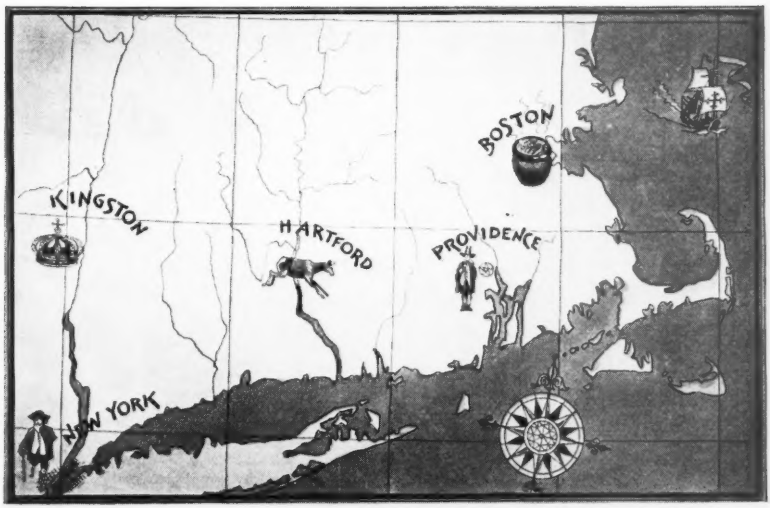

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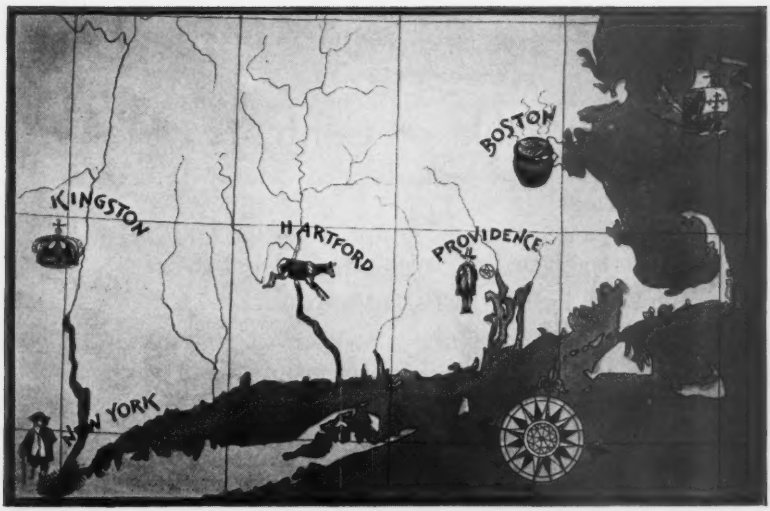

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New England Water Works Association

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

PUBLIC WORKS AND STATE BOUNDARIES.

BY CLEMENS HERSCHEL.*

[*Read September 14, 1927.*]

Perhaps the greatest hindrance to the free and efficient construction of public works that there is in these United States, is met with, as most engineers have no doubt experienced, when these works, or their attributes, lie across the boundaries of the States. Whence it will not be thought strange that two successive presidents of the New England Water Works Association have asked the writer to treat the subject named in our JOURNAL. It is a topic of great and increasing importance, and one that is encountered in the construction of public works with increasing frequency.

Scores of millions of dollars are wasted, merely to avoid crossing state lines; wasted in comparison with what could be accomplished were there reciprocity between the States in matters of public-works construction, as there is in trade and travel. In times past, the difficulties to be met with have officially been considered to be "insurmountable." But in an increasing number of analogous cases they have already been surmounted, giving promise of ways and means yet to be found that will give more freedom in the construction of public works of this sort.

It is common knowledge that the States of the Union are sovereign States, except in so far as they are subject to the Constitution of the United States, which came into force in June, 1790. It was a curious world in that year, 1790, when compared with the world, and its needs, of 1927.

For one thing, there practically were no civil engineers in the United States in 1790, nor were there any public works. John Smeaton, 1724–1792, acknowledgedly the first man in Great Britain who called himself a civil engineer (in 1788), had no colleagues in this country until some twenty or thirty years later. Before his time there had been military engineers, and land surveyors, but no civil engineers. There had been no occasion for their services, because there were no public works, such as we now know them. These may be said to have begun in Great Britain about the time the Eddystone Lighthouse — the lighthouse that outlasted the rock on which it stood — was built by John Smeaton; completed in 1759; and may

*Hydraulic Engineer, New York City.

be said to have begun in the United States with the advent of "Internal Improvements," about Andrew Jackson's time, all of sixty years later.

The writer is reminded at this point of a report by a Committee of the Great and General Court of Massachusetts that he was told of in his youth, on "laying out a highway to Dedham and the West," which aptly illustrates the state of the country in the matter of public works in its early history and as compared with the world we live in today. The committee duly reported back, that they had attended to the task assigned them and had laid out a highway as far as Dedham; and in their opinion, this was as far west as a highway would ever be needed.

Is it not plain that if public works had been as prominent in the public mind in 1780–1790 as they are today, or if the Constitution of the United States were to be written today, that some recognition of the need of building them across state lines would not have been, or now would not be, omitted from that august charter of our liberties? We have in Sec. 8:— "The Congress shall have power to regulate commerce with foreign Nations, and among the several States, and with the Indian Tribes"; and it is easy to see that the United States of the day, and since then, might have been a complete failure without such a provision for the common good. Without it, the States, or some of them, would inevitably have set up custom houses and passport regulations on their frontiers; just as certain misguided parties, looking only to their immediate, and apparent, though grossly selfish interests, are continually trying to do something of the sort even now; and thus would have come to naught the much greater universal benefit enjoyed by the people of the United States in having free trade and travel throughout the country; whatever it may be with "foreign Nations" and "the Indian Tribes."

Query: Has Congress now the power to regulate the particular kind of "commerce* among the several States" which would enable the citizens of one State to build works for their supply of drinking, or, if one pleases, irrigation, water, from and over the soil of another State?

But there were no public works to be provided for in 1790, as has been said. And thus we of today are relegated to all sorts of makeshifts and emergency measures, to meet our wants in the line of interstate public works.

These methods have been suggested, and certain of them have been put to work:

1. A "compact," or treaty, between the affected States.
2. Concurrent legislation, by the adjoining States.
3. Equitable relief through the action of the Federal Courts.
4. Confining himself to the cases that especially interest us at this time, the writer will add a fourth method, — to consider the supply of water to municipalities as a commercial, rather than a governmental, function to be exercised; and then to proceed as is done in other commercial under-

*Commerce means, among other things, intercourse, or dealing with.

takings, such as railroads, for example, that cross state lines. And, let us agree, there should be no more difficulty in providing municipalities with water for domestic purposes, or to build main drainage lines of sewers, as interstate undertakings, than there is to build an interstate railroad.

1. Interstate Compacts.

This is the form of proceeding contemplated by the Constitution of the United States; and many such compacts on a variety of subjects have been consummated; with others pending as this is written.

A notable such interstate treaty upon a matter of practical hydraulics is that relating to the distribution of the waters of the South Platte River for purposes of irrigation between the States of Colorado and Nebraska, approved by Colorado legislation, February 26, 1925. It took seven years of negotiation to conclude this compact, but it caused a long-pending law suit between these States to be dismissed, and has, since 1925, given general satisfaction to all the parties concerned.

To become effective, interstate compacts require the consent of Congress.

2. Concurrent Legislation.

This has to recommend it, the exemption of the parties in interest from being obliged to act in joint conference, and to seek the approval of Congress. One such example on an hydraulic subject is found in the relations between the States of California and Oregon as to the withdrawal of water for use by each from the other. The two provisions of their respective Statutes follow.

Appropriation of Water for Use in Another State. The state water commission shall allow the appropriation of water in this state for beneficial use in another state only when, under the laws of the latter, water may be lawfully diverted therein for beneficial use in the State of California. Upon any stream flowing across the state boundary a right of appropriation having the point of diversion and the place of use in another state and recognized by the laws of that state, shall have the same force and effect as if the point of diversion and the place of use were in this state; provided, that the laws of that state give like force and effect to similar rights acquired in this state; provided, that nothing in this act be so construed as to apply to interstate lakes, or streams flowing in or out of such lakes. (California Statutes, 1917, p. 284.)

The Oregon Statute on this subject reads as follows:

Diversion or Use of Water may be in Another State.

Section 1. That no permit for the appropriation of water shall be denied because of the fact that the point of diversion described in the application for such permit, or any portion of the works in such application described and to be constructed for the purpose of storing, conserving, diverting or distributing such water, or because the place of intended use or the lands to be irrigated by means of such water, or any part thereof, may be situated in some other state, but in all such cases where either the point of

diversion or any of such works or the place of intended use, or the lands, or part of the lands, to be irrigated by means of such water, are situated within the state of Oregon, the permit shall issue as in other cases; provided, however, that the state engineer may in his discretion, decline to issue a permit where the point of diversion described in the application is within the state of Oregon but the place of beneficial use in some other state, unless under the laws of such state water may be lawfully diverted within such state for beneficial use in the state of Oregon. (Laws of 1911, Chapter 224, p. 404.)

Referring to what was said above as to a provision of the Constitution of the United States designed to facilitate the construction of interstate public works, is it not evident, from a study of these concurrent resolutions, that such an article of the constitution could very well have been or be now written.

3. Equitable Relief through the Action of the Federal Courts.

Theoretically, this sounds all right. Practically, the experience, for example, of Kansas and Colorado (in sharp contrast to that of Colorado and Nebraska, cited above under 1), is enough to deter any one from recommending that form of expected relief. The Kansas-Colorado case, relating to the uses of the Arkansas River, has been in the courts for more than twenty-five years, and the end is not yet.

4. Multiple State Charters.

It has been frequently held that furnishing a supply of water for domestic uses does not constitute on the part of a municipality an exercise by it of any governmental function. It is a mere going into business by the town or city. Such being the case, a way seems to open for such corporations to become empowered to build the named public works any- and every-where, and without regard to whether the map shows the needed lands as colored red, or colored green. The ruling considerations may then be those the engineer finds on the earth as God made it; being those of elevation above sea-level, boundaries of drainage areas, courses of rivers and brooks, and topography in general.

The main difficulties of procuring legislation in any one State, on a matter of no direct importance to it, or to any of its citizens, could then be obviated by throwing open subscriptions to the stock of the water company to any and every body, at least up to the limit of one less than half the number of shares to be issued, with the interested municipality in reserve, to take up all that remained unsubscribed. It might then be readily possible for a large city, the capital for all practical purposes of a much greater than its political territory, to act, when it was a question of supplying itself with water, as though it were in fact and in politics the capital of the greater territory named.

There is at least one case in the United States where a city managed to supply itself with water for domestic purposes by a commercial proceed-

ing of the kind above described, and — what is still more remarkable — without any special legislation looking to that end. Cumberland, in Maryland, is the principal owner in and of the Evitts Creek Water Company, which supplies water to the public in Cumberland Valley Township, Penn., and carries the surplus to the city of Cumberland, in Maryland.

Certain busybodies attempted to question and prevent a proceeding so subversive of all true patriotism, but failed in their nefarious undertaking; and at last accounts, very few of the neighborhood were any the wiser as to the exact sources of the water used in Cumberland, Md., for cooking, drinking, and other domestic uses.

There is also one other precedent for such a commercial proceeding, on the part of a city, that occurs to the writer of this article. Many years ago, the city of Cincinnati, as principal stockholder, built the Cincinnati Southern Railroad. Once let a city rob itself of the delusion that it is exercising a governmental function in building works for the water supply of its citizens, and there should be no difficulty in its getting a sufficiency of charters to build such works, wherever nature allowed them to be placed to the best advantage.

As a matter of fact, there are two general classes of cases met with in the construction of what may be termed interstate works of water supply. In the one class, the works themselves cross the boundaries of the States; in the other, the sources of the water to be conducted are affected with a multiple state character; and, of course, certain works may be listed in both of these classes. In what has been said above, emphasis has been laid upon the first-mentioned class of cases alone, but the sources of the water to be supplied make for quite as much difficulty of execution of the works, as the rights attached to the soil to be covered by these works.

To discuss this latter branch of our enquiry would lead us into a study and a review of all that the Federal Courts have said upon this important and intricate and strictly legal subject. It is one, also, in which each case presents features peculiar to itself alone, and general rules would be difficult to establish. But as the writer has before him much work of the kind named, that has already been done, he will cite cases, for the benefit of lawyer aids to engineering work, that may read this.

A neat decision is that in the case of *Wyoming* v. *Colorado*, June 5, 1922; final decree, October 9, 1922; 257 U. S. 410; confirming the right of Colorado to divert 18 000 acre-feet of water per annum from the Laramie River.

It should be noted in reading about this and other Western irrigation cases, that the old English doctrine of riparian rights does not hold in many of the Western States. Riparian rights will do well enough in a little country like Great Britain, dripping with moisture the greater part of the year; but are wholly out of place in lands whose agriculture depends on irrigation, such as the greater part of Spain and Italy, and of many of our Western States. In these latter cases there is substituted the doctrine of

"prior appropriations." Happily, in both Wyoming and in Colorado, prior appropriations had long been the recognized rule of law. Said the Court:

"In neither state was the right to appropriate water from this interstate stream denied. On the contrary, it was permitted and recognized in both. The rule was the same on both sides of the line. Some of the appropriations were made as much as fifty years ago and many as much as twenty-five. In the circumstances we have stated, why should not appropriations from this stream be respected, as between the two states, according to their several priorities, as would be done if the stream lay wholly within either State? By what principle of right or equity may either state proceed in disregard of prior appropriations in the other?" . . . "Both states pronounce the rule just and reasonable as applied to the natural conditions in that region; and to prevent any departure from it, the people of both incorporated it into their constitutions. It originated in the customs and usages of the people before either state came into existence, and the courts of both held that their constitutional provisions are to be taken as recognizing the prior usage rather than as creating a new rule. These considerations persuade us that its application to such a controversy as is here presented cannot be other than eminently just and equitable to all concerned."

Thus establishing in certain respects a *modus vivendi* across a state line as though the line did not exist.

Another point to be noted, by engineer readers more especially (lawyers know all about it), is the consideration that running water, under both English and Roman law, cannot be made the subject of private ownership. Its use is regulated by statute. Only when spring water is "captured" before it leaves the premises on which it originates, can it be treated like other products of the soil, such as gas, oil, coal, or minerals generally.

In conclusion the writer's thanks are returned to Elwood Mead, Commissioner of Reclamation, Washington, D.C., and to Thaddeus Merriman, Chief Engineer, Board of Water Supply, New York, N.Y., who have furnished much of the data that enabled this article to be written.

As above said, there follow the citations of a lot of cases bearing on the general subject, and given here only because they are at hand and are

"Footprints that perhaps another,
Sailing o'er life's solemn main,
A forlorn and shipwrecked brother,
Seeing, may take heart again."

Memorandum of Law — Interstate Compacts.

"No state shall, without consent of Congress, . . . enter into any agreement or compact with another state." (U. S. Const. Art. I, Sec. 10, Par. 3.)

"Consent of Congress" may be obtained either before or after conclusion of the compact and may be either express or implied. The adoption or approval of proceedings taken under the compact indicate consent. "The Constitution makes no provision respecting the mode or form in which the consent of Congress is to be signified, very properly leaving that matter to the wisdom of that body, to be decided upon according

to the ordinary rules of law and of right reason." (*Green* v. *Biddle*, 8 Wheat. 85; *Va.* v. *W. Va.*, 11 Wall. 39; *Va.* v. *Tenn.* 148 U. S. 503; *Wharton* v. *Wise*, 153 U. S. 173; *Holmes* v. *Hennison*, 41 Pet. 571. (Story on Const., 4th ed., vol. 2, chap. xxxv.)

When consent is given "then the States were in this respect restored to their original inherent sovereignty; such consent, being the sole limitation imposed by the Constitution, when given, left the States as they were before, as held by this court in *Poole* v. *Fleeger*, 11 Pet. 209; whereby their compacts became of binding force, and finally settled the boundary between them; operating with the same effect as a treaty between sovereign powers. That is, that the boundaries so established and fixed by compact between nations, become conclusive upon all the subjects and citizens thereof, and bind their rights, and are to be treated to all intents and purposes, as the true, real boundaries. . . . The construction of such a compact is a judicial question." (*R. I.* v. *Mass.* 12 Pet. 657, 725, 731.) "The compact is a law to the sovereigns who enter into it, and is equally a law to the citizens. It regulates the rights and remedies of all who are affected by it." (*Fleeger* v. *Poole*, 1 McLean, 191. See also *Bennett* v. *Boggs*, Baldw. 60; *Spooner* v. *McConnell*, 1 McLean, 337; *Green* v. *Biddle*, 8 Wheat. 1; *Va.* v. *Tenn.* 148 U. S. 503, 517–528; *Wharton* v. *Wise*, 153 U. S. 155.) See above cases for general discussion of the right of States to enter into compacts.

Among compacts approved by U. S. Sup. Ct., in boundary cases, see *Va. and Penn.*, 1780 (11 Pet. 20); *Va. and Penn.*, 1784 (3 Dall. 425); *Ky.* v. *Tenn.*, 1820 (11 Pet. 207); *Va. and Tenn.*, 1802 and 1856 (148 U. S. 503, 511, 516); *Va. and Md.*, 1785 (153 U. S. 155, 162). Respecting boundary rivers, see *Wash. and Ore., Columbia River; Md. and Va., Potomac River* (153 U. S. 155). See also recent harbor control compact, N. Y. and N. J.

New states are admitted into the Union upon an equality and all the powers of sovereignty and jurisdiction which pertain to the original states and such powers may not be constitutionally diminished, impaired or shorn away by any conditions, compacts or stipulations embraced in the act under which a new state was admitted. *Coyle* v. *Smith*, 221 U. S. 559; *U. S.* v. *Sandoval*, 231 U. S. 28; *Tex.* v. *White*, 7 Wall. 700; *Pollard* v. *Hagan*, 3 How. 223; *Scott* v. *Sandford*, 19 How. 612; *Ill. C. R. Co.* v. *Ill.* 146 U. S. 434; *Ward* v. *Race Horse*, 163 U. S. 514; *Ks.* v. *Colo.* 206 U. S. 46.

Consent of Congress restores to full sovereignty of independent nations. Principles of international law are applicable to interstate streams (*Kas.* v. *Colo.* 185 U. S. 125; 206 U. S. 46) and of interstate compacts "the rule of decision is not to be collected from the decisions of either state, but is one . . . of an international character." (*Marlett* v. *Silk*, 11 Pet. 1, 23.)

International Rivers.

For international law respecting claims of lower nation to waters having their origin in upper nation, see 21 Ops. U. S. Atty. Genl. 274, 282; also Op. U. S. Atty. Gen. Aug. 20, 1919, *in re Colo. River*.

Controversies respecting international rivers are settled (1) by treaty or (2) by war. See *Convention for Equitable Distribution Waters Rio Grande*, Malloy, Treaties, Vol. 1, p. 1202, and above cited cases. Interstate controversies are settled (1) by interstate compacts or agreements or (2) by decision of the U. S. Sup. Ct. (a substitute for war), *Kas.* v. *Colo.* 185 U. S. 125; 206 U. S. 46; *R. I.* v. *Mass.* 12 Pet. 657.

Compacts may be made in full accord with physical and other conditions without regard to strict legal rules. If conflict is allowed to become acute and litigation follows, an equitable apportionment of waters of interstate rivers will be made by the Supreme Court, having due consideration to natural conditions, local laws, etc. See *Kas.* v. *Colo.* 206 U. S. 46, and *Wyo.* v. *Colo.* 259 U. S. 410.

Compacts between States and United States.

Compacts between two or more states are usually formulated by joint commissions. Commissioners are appointed with previous legislative authority or by the executives subject to subsequent legislative approval of compact. Right to negotiate compacts is founded upon sovereignties of states or of states and the United States "each sovereign with respect to the objects committed to it, and neither sovereign with respect to the objects committed to the other." (*McCulloch* v. *Maryland*, 4 Wheat. 316, 400, 410. See also *U. S.* v. *Texas*, 143 U. S. 621, 646; 162 U. S. 13; *U. S.* v. *La.* 127 U. S. 182, 189. *Sturges* v. *Crowninshield*, 4 Wheat. 122, 192; *Gibbons* v. *Ogden*, 9 Wheat. 1, 187; *Chisholm* v. *Ga.* 2 Dall. 419, 425. *Tex.* v. *White*, 7 Wall. 700, 725; *Collector* v. *Day*, 11 Wall. 113, 124; *So. Car.* v. *U. S.* 199 U. S. 437, 448, 454. *Kans.* v. *Colo.* 206 U. S. 46, 87, 97, 117. *N. Dakota* v. *Minnesota*, 263 U. S. 365.)

Postscript. This paper was written and revised before the writer knew of, or saw, Paper No. 1619 in the June, 1927, volume of the Transactions of the American Society of Civil Engineers, and the Discussion upon it, on "Interstate Water Problems and their Solution." This comprehensive and able paper treats the subject mainly from the standpoint of irrigation needs, and the paper presented above may be said to be complementary to it. It has not been changed since the reading by the writer of Paper No. 1619.

Another development has been the rendering of a most important decision by the United States District Court on the exercise of the power of eminent domain even though the plant served by condemnation of land lies across the state border. The opinion follows:

Colgate v. *Philadelphia Electric Company.* Federal Reporter (2), 20, 1927, p. 263. The plaintiff brought action to enjoin the defendant from condemning property in Pennsylvania for the overflow purposes of the Conowingo Dam in Maryland, which is to supply power to a generating plant likewise in Maryland designed to serve Pennsylvania consumers. In discussing the application the United States District Court said: "The plaintiff's lands, as he views it, are to be taken by a Pennsylvania corporation, having the right to the exercise of the power of eminent domain for public uses here, for the benefit of a Maryland corporation serving a Maryland public. This, it is confidently asserted, cannot lawfully be done. The defendant corporation is, however, one of that class of corporations which goes by the descriptive name of a public service corporation. It is created for the purpose of the supply of light, heat and power to the public. It must have land to enable it to serve the public use. It may, therefore, have conferred upon it the power of eminent domain, as has been conferred, to be exercised under the conditions with which there has been or will be a compliance before the power can be exercised. A generating plant is required; this of like necessity calls for a dam. The available site happens to be in Maryland. A Maryland corporation was, because of this, created to do what was required to be done in Maryland; but the fact remains that the plaintiff's lands are none the less being taken for the at least avowed purpose of a public use to serve the Pennsylvania public. Such a use is necessarily, in this as in all cases of the taking of private lands, a prospective use. No court could restrain the taking otherwise than by a finding that the avowed public use was not a public use. This finding we could not now make. The ultimate right to lands in Pennsylvania is in the commonwealth. It may resume its possessions and control of them when the lands are required for public

use. The constitution of the state recognizes this reserved power to take. The people have voluntarily imposed upon themselves a condition, without compliance with which the power cannot be exercised. This condition is imposed by that provision of the constitution which is to the effect that private property cannot be taken for public use without just compensation, paid or secured to be paid. There is no other condition than that of compensation, and no averment in this bill of a failure to comply with this. In theory, as well as in very practical effect, no property owner is deprived of his ownership by a taking by a corporation through the exercise of the power of eminent domain. The title acquired by the taker is a base fee. The possession is for the public use, and for that alone. If the use ends, or for any reason the land is not so used, the title reverts to the former owner. If there is any attempt to make other than the public use for which taken, or to divert the property to a private or other use, the owner may recover possession by an appropriate action in ejectment. It is thus clear that the plaintiff suffers no legal injury, nor any irreparable damage, by the exercise of the power of eminent domain for an avowed public use."

For discussion of this paper see page 358.

INTERSTATE WATER RIGHTS.

BY CALEB MILLS SAVILLE.*

[*Read September 14, 1927.*]

"*Sic utere tuo ut alienum non laedas.*"

NOTE: "So use your own that you may not injure another's."

Riparian proprietors upon both navigable and non-navigable streams are entitled, in the absence of grant, license, or prescription limiting their rights, to have the stream which washes their land flow as it is wont to do by nature, without material diminution or alteration (Gould, on Waters, p. 359). The proprietors, however, have no property in the flowing water, which is indivisible and not subject to riparian ownership, but they may use it for any purpose to which it can be applied beneficially and without material injury to others' rights.

The rights of the nation or State in flowing waters are classed among the regalia or prerogative rights of the sovereign and are accorded by common law as incident to the powers of government for the protection of the realm.

With the growth in population and industry has come the need for increased water supply and the demand, outrunning the available capacity of local or intra sources, is increasingly affecting those more abundant reserves which are to be found in the larger rivers.

Be they large or small, most, if not all, of the States are crossed by streams carrying, in a common channel, the drainage from areas located in several States. These watercourses are called interstate streams, and the matter of their utilization presents many interesting as well as puzzling questions.

Because this matter has become one of considerable importance in water-supply work, it is the purpose of this paper to bring together some facts, history and comment relative to the subject, without presuming too far upon the domain of State and Federal constitutional law.

By ancient custom and law the right to have a stream run its natural course is incident to the land, and a river which flows through the territory of several States or nations is common property.

No nation, however, is justified in doing anything which will deprive another of its rights and advantages. In the language of ancient common law, "*Aqua currit et debet currere, ut currere solebat*"; that is, water runs naturally, and should be permitted so to run, so that it may be enjoyed in its running by those through whose land it passes.

Among sovereign nations the interruption of flow or the injury to the

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water of an international stream might be a cause for war, unless amicably settled by mutual agreement.

Sovereign powers still pertain to the several States of the Union except so far as those States have abrogated the right by assignment to the Federal Government.

The power and authority of the Federal Government as regards interstate streams are expressly limited to regulation for the purpose of navigation; all other interest, power, and authority, both sovereign and proprietary, belong to the States or to individuals.

The right in flowing water, whether sovereign or proprietary, is merely the usufruct, and is not ownership of a property. The title of the State to its watercourses is not proprietary but is limited to a holding in trust in a common property for the benefit of its citizens. In the exercise of this trust, however, it may invoke all its police power.

As far back as the time of Edward III, an assize of nuisance was brought on account of a trench having been made, by means of which a part of the water was withdrawn from a river. The Court passed for the plaintiff and ordered the water restored to the old channel at cost to the defendant.

In the case of *Saunders* v. *Bluefields Water Company* (58 Fed. 133) the Court said: "The appropriation of the water of a non-navigable river by a riparian owner in such quantities as unreasonably to diminish the supply of other riparian owners is a private nuisance for which an injunction will lie."

Again, in the case of *Belfast Paper Works* v. *Boyd* (Ir. L. R. 21, En. 560) the Court said: "a riparian proprietor has no right to divert the water of a stream into a reservoir for the purpose of supplying manufacturers and others with water, where the diversion amounts to a substantial diminution of the water."

"One State cannot authorize changes in a river which will injure property in another State (*Holyoke Water Power Co.* v. *Conn. River Co.*, 52 Conn. 570). An upper State cannot divert water to the injury of property or the destruction of navigation lower down, and attempts to do so will be restrained by Courts having jurisdiction. Nor has the upper State a right to pollute the water in such a way as to render it unfit for domestic use in the lower one . . . ." An action to prevent injury to property in another State may be brought in the courts of the one where the act is done and the defendant resides, although the injury occur in the other State (*Mannville Co.* v. *Worcester*, 138 Mass. 89, 52 Am. Rep. 261; *Bannigan* v. *Worcester*, 30 Fed. 392, etc.), and the action may also be brought where the injury is done (*Thayer* v. *Brooks*, 17 Ohio, 489, Am. Dec. 474).

As the right to declare war is expressly assigned to the Congress of the Federal Government, disputes between States regarding rights in interstate streams, and damage thereto, must be dealt with either by treaty (com-

pact), the legislative method, or by appeal to the United States Supreme Court, — the judiciary method. The power to make treaties or compacts between States, as stated in section 10 of Article I of the Constitution of the United States, is: "No State shall, without the Consent of Congress, . . . enter into any Agreement or Compact with another State . . . " the affirmative of which is that any State with such consent may make agreements or compacts for the mutual good.

The rule of "Reasonable Use," however, may be invoked, and in order to give a lower owner a right to complain of the diversion of the water from a stream by an upper owner, the former must show that his rights are interfered with in such a way as to cause injury to him (Farnham, on Water and Water Rights, vol. ii, p. 1651). But after an upper owner has made particular use of the water for some time, it is difficult to show that he has no right to continue such use, therefore the lower owner has a duty to take steps to prevent the destruction of rights which belong to him, and which he may at some future time wish to make use of, although not using them at the time he brings suit. In case action is not brought, a prescriptive right may be acquired by the other party. The law will presume injury from such a condition (*Hart* v. *Evans*, 8 Pa. 22), but the relief granted will be merely a vindication of his right, and he cannot receive special damages unless he shows that he has received special injury, "*Damnum absque injuria.*"

In the modern doctrine of law, possession by prescription is based on the principle that uninterrupted exercise of a right, "during the time whereof the memory of man runneth not to the contrary," supplies the right of a legal title and establishes claim on the part of the possessor (*Wallace* v. *Fletcher*, 30 N. H. 444, 445).

In establishing an adverse water right, the leading case in England is *Beaty* v. *Shaw*, wherein the plaintiff alleged that a stream of water formerly flowed through his land but that the defendants widened and deepened certain sluices and thereby diverted a greater quantity of water than had previously been done. The question was as to the quantity of water to which the defendant was entitled. By virtue of uninterrupted enjoyment, Lord Ellenborough, C.J., said: "The general rule of law, as applied to this subject, is, that independent of any particular enjoyment used to be had by another, every man has a right to have the advantage of a flow of water in his own land without diminution or alteration, but an *adverse* right *may* exist, founded on the occupation of another. And, although the stream be either diminuted in quantity, or even corrupted in quality, as by means of the exercise of certain trades, yet if the occupation of the party so taking and using it, have existed for so long a time as may raise the presumption of a grant, the other party, whose land is below must take the stream subject to such adverse right." Most of the statutes of limitation in the United States, like the English statute of James I, 16, prescribe a period of twenty years for the right of entry upon land held adversely (*Watkins* v. *Peck*, 13 N. H. 360).

There seems to be no doubt but that prescriptive rights can be acquired against private interests and even against the Government itself, but no length of time will substantiate a right to exclude the public from the use of navigable water, although if the adverse act is done under state grant and merely curtails boating privileges for a special period of each year, while the advantage of the diversion is great, a court decision of "*Damnum absque injuria*" (loss without injury) is probable.

As running streams are the natural drainage ways of the territory through which they flow, the surface washings and filth from inhabited places become more and more a detriment to riparian owners. This injury, however, is so slight when compared to the common good that until the amount of excrementitious matter and other wastes becomes sufficient to interfere materially with the purity usefulness of the water to lower riparian owners, there is held to be no serious cause for complaint.

The fact that fish are driven away from a stream is not such an injury as will entitle a riparian owner to complain, and the reasons that fish frequent or leave a certain place are held not to be matters which a court will investigate.

How far the State itself can go in legalizing nuisances within its borders, as by giving authority to discharge sewage or waste into flowing water within its territory, has not been definitely settled. It is, however, the undoubted right and duty of the State to protect the interests of all of its citizens.

The basis of suit to prevent injury to state interests by diversion of water from an interstate river above the boundary line appears to lie in interference with navigation, by materially reducing the flow of the stream and by causing nuisance to lower riparian owners by the discharge of excrementitious and other wastes in larger quantities than the flow of water in the stream is capable of carrying without obnoxious effect.

The fact that the right to discharge such waste matter into the stream may have been acquired by prescription by an upper riparian owner, does not appear to be a valid defense in case of diversion by an upper proprietor, because the complaint does not lie against the discharge of the waste but against the lessening of stream flow to such an extent as to be tantamount to increase in waste discharge and therefore of present detriment.

That a lower riparian owner in discharging sewage and waste into a stream which, combined with the wastes from above, creates the nuisance, seems also immaterial because under the basic principle of riparian law an upper proprietor has no right to so change the character of the flowing stream that the lower owner may not use it for his own benefit as it flows by.

It appears from the foregoing that lower riparian owners as individuals may have cause for action against diversion of water from a stream by an upper proprietor if the stream is materially lessened in amount; and that a State may have cause for action on account of interference with public uses such as navigation, wastes disposal, and other benefits to which the public of the State had a right under common-law conditions.

From what has gone before, it is plain that the matter of ownership and use of water flowing in a stream has become considerably a question of law, the equitable application of which, however, depends upon many circumstances that are not of primary legal significance.

At the outset, it is desirable to differentiate between "surface water," so called, and "underground water"; as the laws concerning each are very different. Underground waters may be considered as of two distinct classes: first, those which flow in defined and known channels, and the laws applicable to these are the same as those which apply to streams on the surface of the ground. These laws, however, have no application whatsoever to water passing through the ground below the surface without a definite channel, or in courses which are unknown. The most fundamental distinction in law between surface waters and underground waters of the second class is recognition of certain rights only in the former, i.e., usufruct, whereas the latter admits of absolute ownership.

Broadly speaking, the matter of surface-water usefulness may be considered under three heads: Riparian Rights, Prior Appropriation, and Reasonable Use.

The English common-law view of riparian rights — and this is the basis of surface-water law in the eastern portion of the United States — was well summarized by Lord Macnaghter in the British House of Lords in 1893 (*Young* v. *Sankier Distillery Co.*):

> "A riparian proprietor is entitled to have the water of a stream, on the banks of which his property lies, flow down as it has been accustomed to flow down to his property, subject to the ordinary use of the flowing water by upper riparian proprietors, and to such further use, if any, on their part in connection with their property as may be reasonable under the circumstances. Every riparian proprietor is thus entitled to the water of his stream, in its natural flow, without sensible diminution or increase and without sensible alteration in its character or quality. Any invasion of this right causing actual damage, or calculated to found a claim which may ripen into an adverse right, entitles the party injured to the intervention of the Court."

While these principles are applicable to both public bodies and private persons, private rights may be superseded by the acquisition of a prescriptive right, which, however, cannot obtain in the case of public rights.

The Massachusetts courts have been particularly insistent in protecting the rights of riparian owners along the lines laid down by English Common Law, for example, in the case of *Parker* v. *American Woolen Co.* (195 Mass. 591) the Court regarded it "as settled that no riparian proprietor has the right to use the waters of a natural stream for such purposes or in such a manner as will materially corrupt it, to the substantial injury of a lower proprietor, or to cast or discharge into it noxious or deleterious substances which will tend to defile the water and make it unfit for use."

At first sight it would appear quite clear what must not be done by an upper riparian owner; but just what does this mean? The Common Law

is specific as regards riparian proprietors; but are States riparian owners, that is, do the same rules that apply to private persons, or corporate bodies within a State, apply with equal force to two sovereign States each of which is supreme within its own territory except as limited by the Federal constitution? Again, what is "sensible diminution or increase" or "sensible alteration in its character or quality," and what use by an upper riparian owner is "reasonable under the circumstances"?

The first and most important matter seems to be status as regards international law. Controversies respecting international rivers are settled (1) by treaty or (2) by war. Interstate controversies are settled (1) by interstate compacts or agreements or (2) by decision of the United States Supreme Court (a substitute for war). As in most other legal controversies, the ways of the Court, at first sight, seem devious and somewhat confusing to the lay mind, but further study and consideration from several viewpoints usually results in greater respect for law and established precedent.

In the case of international rivers, the rights of the United States to the interflow of the Rio Grande River, irrespective of any former uses in Mexico, was upheld by the opinion of the Attorney-General in 1895 (21 Ops. Atty.-Gen. 274, 282), it being held that "The fact that there is not enough water in the Rio Grande for the use of the inhabitants of both countries for irrigation purposes, does not give Mexico the right to subject the United States to the burden of arresting its development and of denying to its inhabitants the use of a provision which nature has supplied entirely within its territory. The recognition of such a right is entirely inconsistent with the sovereignty of the United States over its natural domain"; and this opinion was restated in 1903 in the controversy with Mexico concerning the Colorado River, to the effect that "the United States has a perfect right to divert the waters of the Colorado River at any point above the international boundary with Mexico, irrespective of the effect of such diversion upon the flow of the river in Mexico or along that part of its course which forms the boundary between the two nations" (Rep. to Atty.-Gen. of U. S., Colorado River in California, p. 58; Op. Atty.-Gen. Aug. 20, 1919).

Notwithstanding these opinions upholding the right of the United States to the use and benefit of the entire flow of the Rio Grande River, the rights of the two nations in accord with advice of the Attorney-General were actually treated as a matter of policy and settled by a "Convention providing for the equitable distribution of the waters of the Rio Grande for irrigation purposes." (Malloy, Treaties, vol. i, p. 1202.)

In regard to the sovereignty of the States, in the case of the *United States* v. *Louisiana* (U. S. *v.* La. 127 U. S. 182, 189), it was stated, "it is matter between two sovereign powers." In the case of *Chisholm* v. *Georgia* (2 Dall. 419, 435) it was stated, "Each State of the Union is sovereign as to all powers reserved," and in the Constitution itself (10th Amendment),

"The powers not delegated to the United States by the Constitution are reserved respectively to the people."

As, therefore, the States themselves are sovereign except so far as they have delegated their powers to the Federal Government, it would seem to follow that the principles of international law are applicable to the use and distribution of waters of interstate streams. In the case of *Mallett* v. *Silk* (11 Pit. i, 23) the Court said: "the rule of decision is not to be collected from the decisions of either State but is one, if we may so speak, of an international character."

Notwithstanding these indications of the right of sovereign States to keep and hold for their own use and benefit, if desired, all of the water flowing in an interstate stream, regardless of effect of the public and private proprietors further down the stream, it is customary for States to settle their various controversies, including distribution of water in interstate streams, by compact or by concurrent State Legislation. In the case of *Kansas* v. *Colorado* (185 U. S., 206, U. S. 45) the United States Supreme Court held that the respective States were each entitled to an equitable portion of the waters of a common river, the extent of use in each State being determined upon the facts and circumstances. In the case of *Washington* v. *Oregon* (214 U. S. 205, 218) the Court recommended settlement of the controversy by interstate compact.

In the case of *Kansas* v. *Colorado* (206 U. S. 46, 87-97) the Court said: "One cardinal rule, underlying all the relations of the States to each other, is that of equality of right. Each State stands on the same level with all of the rest. It can impose its own legislation on no one of the others, and is bound to yield its own views to none." Nevertheless, in concluding, the Court dismissed the case without prejudice to the right of Kansas to institute new proceedings "whenever it shall appear that through a material increase in the depletion of the waters of the Arkansas by Colorado . . . the substantial interests of Kansas are being injured to the extent of destroying the equitable apportionment of the benefits between the two States resulting from the flow of the river" (206 U. S. 46, 117).

The Law of Prior Appropriation.

The common-law rule of riparian rights is rejected and the rule of rights by prior appropriation is established in at least seven States, including Arizona, Colorado, Idaho, New Mexico, Nevada, Utah, and Wyoming.

In eleven States the law of riparian rights is replaced, modified by appropriation rights vested before the land passed to private ownership, viz., Alaska, California, Kansas, Montana, Nebraska, North Dakota, Oklahoma, Oregon, South Dakota, Texas, and Washington.

In the States touched by the Mississippi River, and all States east of that line, the law of rights by prior appropriation has been repudiated. *The Law of Reasonable Use* is the basis of the court reference in *Kansas* v.

Colorado to the "one cardinal rule, underlying all the relations of the States to each other, [which] is that of equality of right." This rule of prior appropriation, however, appears to be a modification of adverse rights obtained by prescription, which is recognized in ancient English Common Law.

In the matter of specific cases dealing with diversion of interstate waters the following are of special interest. *Kansas* v. *Colorado* (185 U. S. 125; 206 U. S. 46), 1907, "Suit to enjoin a diversion long practiced by and under authority of Colorado, as well as a proposed additional diversion. Dismissed without prejudice on the grounds that, while injury to Kansas was real, regarding the interests of both States and the right of each to receive benefit through irrigation and in any other manner from the waters of this stream, we are not satisfied that Kansas has made out a case entitling it to a decree. At the same time it is obvious that if the depletion of the waters of the river by Colorado continues to increase there will come a time when Kansas may justly say that there is no longer an equitable diversion of benefits and may rightfully call for relief against the action of Colorado, its corporations and citizens, in appropriating the waters of the Arkansas for irrigation purposes."

The Supreme Court decisions in this suit:

1. Affirmed state ownership and control of the waters of non-navigable streams.
2. It defined interstate rights to be an equitable division or apportionment of the benefits arising through the use of waters in an interstate stream.
3. It dismissed the Kansas petition without prejudice on the grounds of insufficient proof of injury.

Wyoming v. *Colorado* (259 U. S. 496; 260 U. S. 1),* 1922. "Suit to prevent a proposed diversion under the authority of Colorado." Decree enjoined the defendants from diverting more than 15.500 acre feet per year by means of the Laramie-Pondre project, determined the "fairly constant and dependable flow" realizable "by means of practicable storage and conservation," and apportioned the whole of this reasonable flow between the two States, on the basis of priority of appropriation.

The Laramie River case, so called, was based on the principles underlying the "Doctrine of Priority" and in substance the decision of the Court:

1. Affirmed the fundamental principle of priority as the proper basis for allocating river flow to established uses in each State when *both* States recognize the same doctrine, but reaffirmed the Kansas-Colorado decision where local laws differ.
2. Held untenable the Colorado contention that a State may use all the water of an interstate stream which originates within its boundaries.

*"Allocation of Water Supplies derived from the Watersheds of Interstate Streams." Leonard P. Wood: *Jour. Am. W. W. Assoc.* vol ii, No. 3, May, 1925, p. 529.

3. Held untenable the Wyoming contention that appropriations of the Laramie River water should be limited to use in the Laramie River Watershed.

In the consideration of water rights it seems apparent that the guiding principle, at the time of the enunciation of an opinion by the Court, was to establish a sound position, "*Tempora mutantur nos et mutamus in illes*" (Times are changed and we change with them). With these changes come different viewpoints. We no longer hang people for small misdemeanors but we seriously treat those who dump polluting offal into domestic watercourses. In other words, safety to life and health has now taken precedence over mere property rights.

In a recent decision of the United States Supreme Court (*Village of Euclid, Ohio*, v. *The Ambler Realty Co.*)* the Court said:

"Regulations, the wisdom, necessity, and validity of which, as applied to existing conditions, are so apparent that they are now uniformly sustained, a century ago, or even half a century ago, probably would have been rejected as arbitrary and oppressive. Such regulations are sustained, under the complex conditions of our day, for reasons analogous to those which justify traffic regulations, which, before the advent of automobiles and rapid transit street railways, would have been condemned as fatally arbitrary and unreasonable.

"And in this there is no inconsistency, for while the meaning of constitutional guaranties never varies, the scope of their application must expand or contract to meet the new and different conditions which are constantly coming within the field of their operation. In a changing world, it is impossible that it should be otherwise."

And so with allocation of water in a running stream, the necessities of a people to have pure and wholesome water will certainly take precedence over the necessity for running a mill; not because the mill is of less value than formerly, but because it is recognized, that, while some water is a necessity of life, for which there is no equivalent, modern art has so advanced that substitute power for running the mills can as well be obtained elsewhere at a price.

Viewed from such an angle, Article VIII of the treaty between the United States and Great Britain, January, 1909, in the matter of Pollution of Boundary Waters, contained the following provisions in respect to the use and importance of the waters in the boundary lakes and rivers:

First: Uses for Domestic Sanitary Purposes.

Second: Uses for Navigation.

Third: Uses for Power and Irrigation.

To these might well have been added, uses for pleasure and recreation, which, while of lesser vital import, are nevertheless of much consequence in present-day life.

Uses for domestic and sanitary purposes include, of course, such uses as are made in the household for drinking, cooking, and washing of person, clothing, utensils. Sanitary purposes include dilution of domestic wastes and its carriage away from inhabited centers. Both of these uses are

*The Nation's Health, vol. ix, No. 1, Jan. 1927, pp. 59–60.

essential to human health and well-being, and therefore, under present-day conceptions, are of first and foremost importance.

The basic principle of riparian rights, however modified, can never be obliterated; and while private rights may be over-ridden by prescription, public rights cannot be so voided. Without exception the riparian communities which pollute streams of running water, whether they be intrastate or interstate, do so in violation of the principles of common law.

Notwithstanding the necessities for preservation and protection of human life, the base principle of riparian rights still holds firm; and while some practices in the interest of public good may be condoned for a time, it is understood that no effort will be spared to obtain a means for correcting the nuisance and preventing the trespass.

In the case of *Parker* v. *American Woolen Co.* (195 Mass. 591) the Court regarded it "as settled that no riparian proprietor has the right to use the waters of a natural stream for such purposes or in such a manner as will materially corrupt it to the substantial injury of a lower proprietor, or to cast or discharge into it noxious and deleterious substances which will tend to defile the water and make it unfit for use . . . ."

The English courts also have held that "The right to use the stream to carry away mere waste matter in a reasonable manner and to a reasonable extent, is not so to be extended as to include the right to discharge into the stream, noxious and deleterious matter to such an extent as sensibly and materially to foul the water and destroy its purity and fitness to be used by others." In England for 50 years extensive and continuous investigations have been under way for this purpose.

The conclusions and recommendations resulting from this study have almost without exception pointed out that the remedy lay in the proper balancing of various conflicting interests.

In jurisprudence the word "injuria" has a somewhat different meaning from that ordinarily given for the term "injury." In the former case it means harm or damage in excess of that which would be of such minor importance as to be negligible. So in the case of flowing waters the "injury" to riparian right might be more theoretical than practical and the limit of permissible pollution and the extent to which pollution might cause "injury" should be carefully considered, so that, on the one hand, the lower riparian owner might not suffer from the acts of him above, and, on the other hand, the upper riparian owner may not be prevented from utilization of the benefits of his proprietorship. In England it is understood that the rivers have been roughly divided into three classes: (1) Those with present practically pure water which is not hereafter to be disturbed; (2) Those now somewhat polluted and which are to be held so far as possible in their present condition; and (3) Those rivers which are now practically open sewers and which it is impracticable to restore, both on account of cost and disturbance of conditions which are the result of a long period of population growth.

Somewhat similar policies have been proposed in Pennsylvania by Mr. W. L. Stevenson, M. Am. Soc. C.E., Chief Engineer, State Dept. Health, who states in his Report that "this policy will safeguard present clean streams and make them available as sources of water supply and for fishing and other recreational purposes"; and that the basis of the plan outlined is predicated upon the assertion that "the natural power of the stream to inoffensively assimilate and dispose of polluting matter by dilution must be utilized as far as comportable with the general interests of the public."

It is generally conceded that where the ratio of the volume of water to the volume of sewage is so large that no local nuisance can result, the method of sewage disposal by dilution represents a natural resource and that the utilization of this resource is justifiable.

What limit for satisfactory dilution may be permissible is a matter which has received attention from some of the ablest hydraulic and sanitary engineers of this and other countries, and while no general rule is adequate because of varying and various local conditions, the résumé of the answers to this question received from the Advisory Engineers on the International Joint Boundary Committee on the Pollution of Boundary Waters is significant (p. 35, Ref. Final Report of the Int. Jt. Comm. 1918): "While present information does not permit a definite limit of safe-loading of a water purification plant to be established, it is our judgment that this limit is exceeded if the annual average number of B. *coli* in the water delivered to the plant is higher than about 500 per 100 cubic centimeters, or if in 0.1 cubic centimeter samples of the water, B. *coli* is found 50 per cent. of the time." In studying this matter Professor Phelps found that "if the sewage of cities be diluted in a stream flow of 4 cubic feet per second per 1 000 of population, the resulting water will contain approximately 500 B. *coli* per 100 c.c."

The so-called self-purification of streams is due to the presence of dissolved oxygen which is required to promote the bacteriological processes by means of which putrescible matter is changed into substances which are neither offensive nor polluting. If the oxygen supply is sufficient, oxidation of the organic matter is accomplished in an entirely innocuous manner. If the oxygen supply is deficient, putrefactive agencies attain control, with resulting putrid odors. As water contains considerably less (perhaps two-thirds as much) dissolved oxygen in summer as in winter, it is evident that the volume of diluting water per unit quantity of sewage should be much greater in summer than in winter to afford satisfactory purification. As the air is the great reservoir from which oxygen is withdrawn by the flowing water, it is also evident that the rougher or more turbulent the stream, the larger amounts of oxygen will be available in the water, and conversely, when there is slight current or pools in which sewage solids may settle, there will be a decrease in natural aëration and consequent reduction in the results of the purifying agencies.

In the Report of the Engineering Board of Review of the Sanitary

District of Chicago (p. 55 *et seq.*, Part 4, Tech. bases for Recommendations, 1925) it is stated that a study of conditions in the Des Plaines-Illinois River indicated that a flow of from "4.5 to 6.0 cu. ft. per sec. per 1 000 human population, or 3.0 to 4.0 cu. ft. per sec. per 1 000 human population and industrial wastes equivalent population, combined," was required, and it was certain that a flow of 3 cu. ft. per sec. per 1 000 human population, or 2 cu. ft. per sec. per 1000 human population and industrial equivalent, combined, was not sufficient to prevent offensive conditions in summer.

In consideration of the injury occasioned by diversion of upper waters of a State, the matter of dilution of sewage discharge appears to be a matter for most serious consideration.

The remedy to get equivalent conditions to those obtaining before the diversion takes place would appear to be the treatment of the sewage before its discharge into the river.

This, however, is a matter of great expense both for installation and operation thereafter; beside this, it is stated in the report, above mentioned (p. 58): "with complete treatment the effluents will contain such substances as carbon dioxide and nitrates which will encourage prolific growth of algae and other water plants. Such growths have been a source of serious complaint in streams carrying a comparatively large proportion of completely treated sewage."

From the above statements it would appear that before diversion of any amounts of comparatively pure water is made from a stream draining a country which is well populated, it would be well to study carefully the sanitary necessities of the river and balance the cost and effect of sewage-treatment works against some other means than complete diversion for obtaining the requisite amount of water. While it is probable that court action in any case will result in confirming to the defendant the right to take water for domestic purposes, it is also as probable that the defendant will be directed to pay highly for sewage-treatment works that will substantially replace water dilution as an agent in preventing nuisance to a lower riparian proprietor. In our New England streams, as will be shown later, a satisfactory alternative may be found in storage reservoirs to conserve flood and freshet flows for use in those periods when the ordinary flow of the stream is too low for proper dilution purposes.

The initial cost of such construction is ordinarily less than that of modern sewage-treatment works, while the maintenance and operating costs are practically "nil" as against ever-mounting annual costs for municipally operated working plants. As to navigation interests, the diversion of water from a stream not only causes shoaling of the channel by lessening the amount of water running therein but it also destroys or at least greatly impairs the beneficial effect of freshet flows in scouring out the channel and preventing the accumulation of incipient bars.

The importance of interstate stream matters has been emphasized more strongly in the western irrigation States than in the East; neverthe-

less, the matter has been brought home to this portion of the country recently by the proposed diversion of flow by the State of New York from the Delaware River and by the State of Massachusetts from the Connecticut River.

As early as 1903, Mr. Elwood Mead, Mem. Am. Soc. C.E., and Mr. R. P. Teele of the United States Department of Agriculture suggested the ultimate need of agreements between States concerning the problems of interstate streams. Recently both Hon. Herbert Hoover, United States Secretary of Commerce, and Mr. Mead have approved the principle of Interstate River Compacts, and Mr. Delph E. Carpenter, Interstate Commissioner for Colorado, has been chiefly instrumental in working out the application of the Compact idea to the settlement of controversies over Western interstate streams.*

Interstate compact accomplishments may be briefly summarized as of May, 1925, as follows (see note, *ante*):

River compacts concluded under negotiation or provided for in Legislative Act	10
River compacts concluded	5
River compacts ratified by interested States	5
River compacts in operation	1
Prospective river compacts	8

Because of its proximity, one of the most interesting proposals for settlement of an interstate water question by compact is that of the allocation of the waters of the upper Delaware River between the States of Pennsylvania, New Jersey, and New York. This matter is of particular interest also from the fact that it is a water-supply problem with which we in the East are most familiar, and amenable to the familiar rules of English Common Law, rather than a matter concerned with irrigation of large areas and considered under the rules of Prior Appropriation. The Delaware rises in the State of New York and flows southerly to the boundary of the State of Pennsylvania near Port Jervis and draining a territory of about 2 390 sq. miles. From thence it flows in a generally southeasterly direction and is the boundary between the States of New Jersey and Pennsylvania. Its drainage area in the former State is about 1 980 sq. miles and in the latter about 6 080 sq. miles.

In spite of its developments within the past 25 years, New York City is now badly in need of additions for water supply for the immediate future. Several localities have been considered, among others the Ten Mile River in the eastern part of the State which has its interstate complications by being an important tributary of the Housatonic River which is one of Connecticut's principal streams, and the Delaware River, as stated above.

Because of its importance to all three of the States mentioned, the project to divert water from so large a part of the drainage area became a

*Interstate Water Problems and their Solutions. Proc. Am. Soc. C.E., April, 1926, 597 *et seq.*

cause for most serious consideration, and early in 1923 the legislatures of the three States authorized their governors to appoint commissioners "for the purpose of negotiating a form of compact or treaty between the three States."

These commissioners, after negotiation, agreed upon a plan for "conserving by storage and otherwise for all uses the water resources of the said States in the Delaware River, its tributaries and drainage area and, as a measure to that end, for making allotments from said water resources to the said States respectively and determining and adjusting their respective rights therein."

This agreement having failed of ratification by two of the States, the commissioners, after further deliberation, drew up a new one similar to the old one but with one or two important changes. This new compact has not as yet been ratified and there is rather severe criticism of some of its provisions, whether or not justly, or for political reasons, is not clear at the present time. The new contract provides that each State can divert "all quantities of water which have hitherto been lawfully diverted by normal operation of all works existing and in actual operation within each State in the Delaware drainage basin when this compact becomes effective, and the future diversion of water in quantities not exceeding those heretofore lawfully diverted by the normal operation of such works, shall not be charged against the total quantity which may be diverted under authority of this article by that signatory State in which said works are located."

Under the first compact each State was to take one-third of the flow above the New York-Pennsylvania line in excess of 0.15 cu. ft. per sec. per sq. mile and the two States below that line were to be allowed one-half the remaining flow less 0.18 cu. ft. per sec. per sq. mile from that area. Under the new compact, the allotment to the three States is as before, but it is further provided that sufficient storage in reservoirs shall be provided to maintain at all times a flow in the river of at least 0.45 cu. ft. per sec. per sq. mile above Port Jervis, and 0.36 cu. ft. per sec. per sq. mile below that point.

The Compact also provides for the organization of machinery necessary and useful in carrying out its provisions, and further provides for proceeding with "study and investigation looking toward a comprehensive and complete development of all the water resources of the drainage area of the Delaware River . . . and to make a study of the possibilities for the development of water power along the channel of the Delaware River. . . ."

The relative "importance and public value" of the waters of the Delaware River are stated in the Compact to be: "A" Domestic and Municipal; "B" Sanitation; "C" Industry and Power; and "D" Navigation. The Compact also provides that all sewage discharged or permitted to flow into the channel of the Delaware River shall, within a reasonable time, be treated to such an extent as to maintain the river in specified sanitary condition.

In commenting upon this Compact the New Jersey Commission (1920)

said: "Independent of compact neither of the three States has a right to all of the waters arising within its boundaries and supplying this interstate stream, but each is entitled to an 'equitable division' or 'equitable apportionment' of the water of the stream." What constitutes an equitable division or apportionment must depend upon circumstances. Its determination requires the consideration of many factors. These factors the foregoing statement provides.

In opposition to the provisions of this Compact, New Jersey interests claimed that the provision for a minimum flow past that State of 0.36 cu. ft. per sec. per sq. mile was too low, and called attention to the fact that Massachusetts, in the case of diversion from the Ware River, required a minimum flow of one and two-tenths cu. ft. per sec. per sq. mile of drainage area. This was stated before Massachusetts passed its Swift River Bill whereby the entire flow from 186 sq. miles has been taken except for 20 million gal. per day, equivalent to about 0.167 cu. ft. per sec. per sq. mile, or less than half the provision made in the Tri-State Compact mentioned above. Other claims and arguments were made in opposition to ratification, the principal one seeming to be that the time was not yet ripe for such a definite allocation. Up to the present time the Compact has not been ratified.

The latest and nearest major diversion of water from an interstate stream is that of the State of Massachusetts for its Boston Metropolitan District from the drainage area of the Connecticut River.

The Massachusetts Legislature of 1926 authorized the diversion of flood flows from 100 sq. miles of Ware River drainage area, providing that at least 1.31 cu. ft. per sec. per sq. mile should flow in the stream under all conditions.

The 1927 Legislature of the same State for the same purpose authorized the diversion from 186 sq. miles from the Swift River with allowance for maintaining a minimum flow equivalent to 0.167 cu. ft. per sec. per sq. mile. Both the Ware and the Swift rivers are Massachusetts streams draining the central part of Massachusetts, and, uniting with the Quaboag River, form the Chicopee River which is a tributary to the Connecticut River from the east about 8 miles north of the Connecticut-Massachusetts State Line and about three miles north of Springfield.

Some other interstate difficulties that have been amicably settled in the past are mentioned below:

In 1917 (see Chap. 316, Special Acts, Mass. 1917) the Legislature of Massachusetts authorized the Town of Methuen, Mass., to contract with the Town of Salem, N. H., for a supply of water. Previous to this, the Legislature of New Hampshire (Chap. 308, Acts, State of New Hampshire 1915) authorized the Town of Salem to sell water to the Town of Methuen, Mass.

It is understood that the States lying in the Ohio River Basin have or are about to enter into an agreement regarding several phases of water-

supply problems, but that nothing has come of this as yet, as the several commissions to which the matter is entrusted, have not as yet ratified the findings of the several engineers representing the interested States. This matter, however, affected sanitary quality of the waters resulting from industrial waste disposal rather than matters of water supply.

The necessity for additional water supply for the large industrial centers in the northeast corner of Rhode Island bordering Massachusetts, will undoubtedly in the near future require interstate action, and for the supply of several Massachusetts communities to the north, it will probably be necessary or at least desirable to go over the line into New Hampshire.

What may be the outcome or result of this diversion to Connecticut and to lower riparian proprietors, can only be ascertained from careful study of the facts, but that it, and contemplated future diversions in the same territory, will have a harmful effect upon both navigation and the sanitary condition of the river at certain seasons of the year, seems self-evident.

In the report of the Joint Board in 1922, relative to water-supply needs of the Metropolitan Water District, the Chief Engineer of the State Department of Health, Mr. X. H. Goodnough, Mem. Am. Soc. C.E., and a valued member of this Association, proposed the somewhat novel and very serviceable plan of utilizing flood flows only in the streams then under consideration. This method, which seemed almost analogous to "eating the cake and having it too," proposed to build storage reservoirs on the streams from which water was to be diverted and store in them only such flows as were in excess of 1.2 cu. ft. per sec. per sq. mile of drainage area. His computations showed that the amount of water required by the Metropolitan District for 50 years to come could be had by this method with no change in the normal flow of the tributary streams during about 57 per cent. of the time. That is, for the 5 low-flow months of the year when the water was needed most, the natural run of the stream would continue without interference. Such a plan, if adopted, would probably have spiked any guns which Connecticut could have trained on the diversion project. As it is now, the combined flow authorized by the Massachusetts Legislature from the diverted watersheds for riparian proprietors is about 0.5 cu. ft. per sec. per sq. mile, — a flow which is only a little more than that proposed by the Tri-State Compact, mentioned above, and which has drawn much effective hostile criticism from some of the interested parties.

The situation now arising in the Connecticut River diversion is the more aggravated by the condition that at times the whole flow of that river above the confluence with the Chicopee River is held for storage during certain days behind the dam at Holyoke and at all times there is a marked diminution of flow over week-ends, due to this cause.

The bearing on sanitation is evident when it is realized that the sewage of Springfield, Holyoke, Westfield, Chicopee, Palmer, and a score or more other thickly settled places is dumped untreated into the Connecticut

River below the Holyoke dam. It is of record that there is plenty of water running in the Connecticut River and its tributaries at certain seasons to serve not only for domestic water supply but for properly diluting the sewage of the tributary municipalities, provided proper conservation plans were made and works constructed. It is probable that the time of treatment of the sewage of the tributary municipalities in Massachusetts, especially Springfield, probably has been brought within speaking distance by this method of diversion, and an enormous cost not only for such treatment but for riparian claims for damage has been saddled upon an unsuspecting public in that State by this recent Massachusetts legislation. Much of this could have been avoided by giving consideration to the constructive plans for water conservation which were proposed.

In order to have some measure by which to compare the run-off authorized by the Massachusetts Legislature with actual conditions of stream flow in approximately the same locality, there is tabulated below the average and minimum yield of the Wachusett Watershed of the Metropolitan (Boston) Water District for the past 30 years.

Month	Average Cu. Ft. Sec. Sq. Mile	Minimum (1911) Cu. Ft. Sec. Sq. Mile
January	1.795	1.196
February	2.007	0.967
March	4.058	2.072
April	3.462	2.155
May	2.014	0.713
June	1.241	0.543
July	0.726	0.087
August	0.600	0.291
September	0.539	0.281
October	0.692	1.111
November	1.181	1.601
December	1.773	1.650
For years of record	1.672	1.055

In comparing these figures with the total amount of water authorized to flow from the diverted areas, 0.5 cu. ft. per sec. per sq. mile, it should be borne in mind that these are *yield* figures and that the actual stream flow would be somewhat greater than these figures, especially in the low-flow months (and these are the critical ones) due to the absence of the evaporation losses which obtain in a large reservoir like the Wachusett, and so lessen the yield. This tabulation shows that at all times the authorized flow from the Swift and Ware rivers below the diversion points is less than the average natural yield of these streams, and this is the condition which must now be considered.

The tributary population north of the Connecticut-Massachusetts State Line and below the Holyoke dam is about 400 000. The area tributary to the Connecticut River between the Holyoke dam and the Connecticut State Line is estimated at 1 170 sq. miles. At 6 cu. ft. per sec.

per 1 000 population there should be a discharge during the summer season (period of low-stream yield) of at least 2 400 cu. ft. per sec., or 2.05 cu. ft. per sec. per sq. mile, which is considerably in excess of the average annual flow of the stream. Dealing with averages; for the period of record this flow is equaled or exceeded during only 2 months of the year, it is nearly four times the average flow for August and September, it is about twenty-one times the mean yield July, 1913, and twenty times the yield of the August following.

Of course the reason that conditions now are not unbearable in the Connecticut River above Hartford is that much, perhaps half of the population on the drainage area is not sewage-producing, due to the rural conditions that prevail. If, however, the sewage-producing population is restricted only in the larger centers and to those communities directly on the river, there are at least 300 000, and probably more, people of Massachusetts discharging sewage directly into the Connecticut River without treatment and within 8 or 10 miles of the State Line. A flow of at least 1.800 cu. ft. per sec., or 1.5 cu. ft. per sec. per sq. mile, is necessary to make this condition sanitary. At times this flow is not available.

The only reason for presenting these facts at the present time is to show that the authorized residual flow of 0.5 cu. ft. per sec. from the 286 sq. miles of diverted watershed seems entirely inadequate to keep the Connecticut River in sanitary condition when this and future diversions are in full swing, and that the 1.2 cu. ft. per sec. suggested by Mr. Goodnough in the report of the Joint Board is the absolute minimum that should have been considered.

If Boston must have this water — and there seems no reason to doubt the necessity — flood flows in excess of 1.2 cu. ft. per sec. would provide the means without particular detriment to river sanitation or navigation. This plan would involve excess flood storage for compensating water either in the same reservoirs as water supply or in special ones constructed for the purpose. The Report of the Commission on Water Ways and Public Lands, 1918 (Mass.) shows that sites for such reservoirs are available. It is also of interest to note that compensating reservoirs might be built on other streams having head waters in Massachusetts and tributary to the Connecticut River between Hartford and the Massachusetts State Line that would be very efficacious by conserving flood flows and releasing the water in times of low flow.

As Connecticut has failed to take formal steps in protest to Massachusetts against a diversion that invades the former's rights which will probably be of much detriment to that State in the future, it is probable, in view of the decision in the Wyoming-Colorado case mentioned above, that at a later day the Court will put the burden of reservoir development upon the lower State to improve sanitary conditions in its portion of the river.

(The following discussion pertains both to the paper on "Interstate Water Rights," by Caleb M. Saville, and to the paper on "Public Works and State Boundaries," by Clemens Herschel.)

Discussion.

Theodore L. Bristol.* I would like to ask Mr. Saville why it is not the lower riparian owners who have claims for damages instead of the State. That is, if they are actual property owners on the stream. If, for example, the State of Massachusetts or the Metropolitan Water District diverts the water of a stream that runs into the Connecticut River, why is it not the lower riparian owners on the Connecticut River who have the claim for damages instead of the State?

Mr. Saville. I presume both may have claims if the withdrawal of water causes damage or affects property or sovereign rights.

The State can claim damages only for what is of state-wide interest. An individual riparian owner will hardly bring suit on account of interference with the navigation in the stream, or on account of general pollution. I should presume that a water-power owner, if he were injured, or if in some other way there were injuries to personal property, would not be estopped in any way from claiming damages.

Allen Hazen.† The question of water laws is much more difficult because in the United States we have two water laws that are entirely different in principle and in application.

That part of the United States that was Spanish at one time, and had Spanish law, still keeps for the most part the principle of Spanish water law; and in this part, which is in a general way the dry part, the doctrine of appropriation is the dominating principle of all water law and procedure.

All the rest of the United States, which is substantially the wet part, has the English law with the doctrine of riparian rights.

The two kinds of law do not mix. Each is better adapted to that part of the country where it is used.

The question of water law in the dry West is very active just now and discussion of that part must be left to the men who live and have their work in that part of the country. Nothing that we can say will add to their discussion. If we attempt to discuss the Colorado River problem from our standpoint of riparian rights, the discussion is lost because we do not have the proper point of view from the standpoint of the Spanish law. Our Western brothers are working this out in their own way. On the other hand, whatever they may do about water laws in the West will not make the slightest difference with what may be done and had best be done in the East where there is more water and the law of water came from England.

J. Frederick Jackson.‡ I want to discuss two points in Mr. Saville's paper. The first relates to the decisions of the courts. I think most every-

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†Consulting Engineer, New York City.
‡Consulting Engineer, New Haven, Conn.

one who has had occasion to study the decisions will recognize and realize that they are to the laymen rather perplexing, in that the court very frequently exercises its prerogative in rendering its decision to discuss the question discursively; these parts of its decision naturally do not have very much weight in law. In studying court decisions, I think engineers will very frequently find that the particular point that they wish settled is frequently passed over in a discursive manner.

The other point that I wish to touch upon is the point made by Mr. Saville in relation to the dilution factor in stream flow in connection with pollution. The courts in Connecticut, in establishing the rule of "safe tolerance," have followed the practice set for the Chicago Drainage Canal, which, in the light of later experience, has been found inadequate.

An interesting illustration of how this rule does not apply is on the Connecticut River, in the stretch from Chester up to Cromwell, just above Middletown. Anyone who is familiar with the river and who has had occasion to be upon it does not need to investigate either the flow of the river or the dissolved oxygen content to know that the river is polluted. Something has happened in that particular stretch there which makes the pollution immediately recognizable to the sense of smell and to the sense of sight very readily. In this stretch the dissolved oxygen content varies from about 13 per cent. to 38 per cent. saturation; if we were to take the whole contributory population of the river above Chester up into Canada we would have a stream flow of about 9 cu. ft. per sec. per thousand, and for Connecticut alone 53 cu. ft. per sec. According to our knowledge today, this should be ample to dispose of the pollution without nuisance or offence to the æsthetic senses. Yet the facts are that that particular stretch of the river, as everyone knows, is particularly badly polluted. The inference then is that each particular case may have some factor in it that must be recognized in applying present standards, or in establishing new standards of stream pollution.

CHARLES S. DENMAN.* Mr. Herschel's paper, as I understand it, makes the statement that the furnishing of water by a city is not a governmental function. This, I think, has been decided by the U. S. Supreme Court in connection with income tax matters where it was held that municipal employees were not subject to income tax for the reason that they were performing a governmental function.

By Act of the 38th General Assembly of the State of Iowa regulating the operating of the water plant at Des Moines, the city was given the right and power to acquire, take over and hold, own, construct, erect, establish, maintain, operate, etc., a water works within its corporate limits and to be the property of the citizens thereof, to be exercised as a governmental function. (Section 1 of the act.)

By reference to Section 15 of the act it will be clearly noted that the employees of the water works are employees of the city, coming most

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clearly within the definition laid down by the U. S. Supreme Court in *Mitchell* v. *Metcalf & Eddy* (269 U. S. 514), which decision is controlling in the instant case and was decided Jan. 11, 1926. The Court held as follows: "This Court has repeatedly held that those agencies through which either the government immediately and directly exercises its governmental powers are immune from the taxing power of the other." Certainly the acts of a legislature affecting the citizenry of a State only as such, obtaining and exercising its powers granted by the Constitution cannot be assailed by the taxing powers of the Federal Government lest by that means the sovereignty of the State should be destroyed and our dual form of government annihilated. The Court further states: "Thus the employment of officers who are agents to administer its laws, its obligations sold to raise public funds, its investment of public funds in securities of private corporations for public purposes, surety bonds by it in the exercise of its police power, are all so intimately connected with the necessary function of government as to follow within the established exemptions, and when the instrumentality is of that character the immunity extends not only to the instrumentality itself but to the income derived from it, and forbids an occupation tax imposed on its use."

J. WALDO SMITH.* Time brings great changes, and as times and conditions change, it seems to me the law, fortunately, accommodates itself to those changes, valued in the light of present-day conditions, whatever these may be. As I understand, if we go back far enough in this State and, I think, in most all the New England States, the man who owned the land around a pond owned the pond. In the early days, in order to avoid future trouble, the State appropriated the ponds of over 15 acres as public waters, to be under the entire control of the State, and the towns are allowed to take water from them as they see fit, with the approval of the State.

In the old English common law certain changes are taking place as time elapses, and we are confronted with new conditions. The decisions made in recent years seem to tend to a rule of reason and common sense rather than any arbitrary interpretation of the old English law.

Of course, in this subject of interstate waters the State and the city of New York are very deeply interested. The best, the cheapest, and the most abundant supply is to be had from the flood waters of the tributaries of the Delaware River, which is a boundary stream between New York and Pennsylvania in its upper courses and between New Jersey and Pennsylvania in its lower courses. In the negotiations carried on in the past five years by duly appointed representatives of New York, New Jersey, and Pennsylvania, with a view to determining the right of each State in these waters, no one at any time presumed to question the right of any one of the States to a fair share. In all the negotiations, which covered months of time, the rights of each State were admitted by all engaged in the nego-

*Consulting Engineer, New York, N. Y.

tiations. On no other basis could the negotiations have been continued. This basic principle having been admitted, it seems to me it would be presumptuous for either of the other States to assert that New York, which has within its own borders a quarter of the whole area of the watershed of that magnificent river, had no rights in its waters. New Jersey and Pennsylvania have rights, and so has New York. I believe that as time goes on the rule of reason and common sense will prevail in all questions relating to the flow of our streams. To be sure, if persons or corporations below any diversions are injured, they should be able to collect damages, and no one could fairly hold to any other view. The only trouble in New Jersey and Pennsylvania, with regard to this Delaware River compact, has been political. There has twice been unanimous and enthusiastic agreement between the commissioners of the three States. The New York legislature has twice approved compacts; the other legislatures failed to approve, without advancing any sound reason. We know that in New Jersey it was not because of the merits of the question, but purely a political consideration. Pennsylvania failed to approve because New Jersey had adjourned without taking action.

Now we are faced with the situation of the city of New York wanting more water, and this needed water should come from the tributaries of the Delaware. We are awaiting the approval of a plan now being considered, and, as we say, we are proposing to go to the bat to determine the rights of the State of New York. This plan, moreover, looks only to the taking of flood water, and the reservoirs will be operated so as to increase the low season flows and will thus substantially benefit conditions all along the channel of the Delaware. The only restraining action I know of that can be taken is for either or both of the other States to apply to the Supreme Court at Washington for an injunction. That court would then hear the case without any intervening court and decide the question on its merits. If one studies the decisions that have been made during the past 15 years, I do not think there is very much doubt as to the final result. There is water enough in the Delaware River for all three States, and their representatives have been perfectly willing to agree on what is the right of each.

X. H. Goodnough.* There is very little I can add to what Mr. Smith has said. In this State there have been quite a number of cases in which interstate streams have been used for water supply, and all of these cases have been settled, I think, amicably, practically by the rule of reason, as Mr. Smith has said.

The taking of the Wachusett supply diverted water from the Merrimack River in New Hampshire as well as in Massachusetts. When that was discussed I remember that the Attorney-General of New Hampshire came into the meeting and said, "Gentlemen, this is an act of war, but we will compound with you for damages"; and they did. They had two cases.

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One was a damage to mill powers, and the other was damage on account of taking away the dilution of the sewage of their towns.

There was another case in the city of Fitchburg, when that city took water from one of the tributaries of the Merrimack River in New Hampshire. It took it inside of Massachusetts. And that was settled in the Massachusetts courts.

There is more difficulty in dealing with some of the States than with others. In Vermont, where there is no eminent domain law, or, at least, has not been of recent years, we have had a case where a town took water near the Vermont border from a stream which drained a large area in Vermont. Certain enterprising people up there found they could buy up some forest land, and they put in some mills along the brook. The question then arose as to how to protect the purity of the water. It was found impossible to do so without buying the land at their price, and that is the way the matter was settled.

The great difficulty which arises when one State takes water out of another State is, to my mind, the difficulty of police protection of the water supply. It is almost impossible to get one State to undertake to protect the supply of another State within its borders. I know, because we have been asked to attempt to protect the supply of a State which takes water partly inside of Massachusetts, and I have never been able to interest the Attorney-General's office in paying much attention to it.

There is another practical side to this question in the case where water is taken by one State within the limits of another State. As you all know, the ideal water supply for the city of Boston has always been thought to be Lake Winnepesaukee in the State of New Hampshire. It is possible to bring that water to the city of Boston, but it is not, it seems to me, a practical thing politically. Of course the consent of the New Hampshire Legislature would have to be obtained, and from my knowledge of legislators I do not believe there is a single legislator in New Hampshire who would ever assent to any proposition to divert that water away from their State and to supply the city of Boston for any reasonable amount of money.

Where the watershed of a stream above the point of taking is wholly within the State, though it may flow out into another, it seems to me that it is simply a question of paying for the damage done to the other State, but I can't see any reason why there should be any restriction on the right of a State to do as it sees fit in such a case, provided it does not do some damage that is irreparable.

GEORGE A. CARPENTER.* This question of interstate control and interstate boundaries is a perplexing one. Pawtucket, for example, takes its supply of water from the Abbott Run, within the boundaries of the State of Rhode Island; but following the stream northerly toward its source, we find it running into Massachusetts and then back again into Rhode Island. We have tried to get coöperative policing from the Massa-

*City Engineer, Pawtucket, R. I.

chusetts authorities, but with little success. As far as the State Board of Health is concerned, I think this could be brought about, but the lawyers seem to make of it a difficult proposition. The question is embarrassing also because there are desirable reservoir sites on Abbott Run within the State of Massachusetts. Not having the right of eminent domain in Massachusetts, we are at the mercy of the riparian owners, as to prices, and if they do not care to sell they can hold up the whole proposition.

M. N. BAKER.* As population becomes denser it is necessary to go more and more to interstate streams for public water supplies. As has been well said, it is the politicians in some of these States who stand in the way of interstate agreements as to the utilization of streams, and they seize upon such occasions as have been presented in New Jersey to prevent the ratification of the tri-state Delaware River compact. Behind the scenes, pulling wires through these politicians, the big electric light and power corporations are sometimes at work. They keep well under cover, and some of the smaller politicians who are working for their interests may not know just what they are doing, beyond following orders from the political bosses.

STEPHEN DEM. GAGE.† The question of interstate rights is of considerable interest to us in Rhode Island, from two viewpoints. We have two water supplies from sources which are almost entirely in Massachusetts. In the case of one of these the water company has acquired rights by purchase on their watersheds and is thus able to obtain a certain measure of control. The other supply is taken from a river which receives more or less pollution from a number of communities located in Massachusetts, where we have no control. Both of these supplies are filtered and chlorinated for safety, but in the latter case, especially, some control of the entering pollution is desirable to relieve the load on the filters. A third supply from a stream rising in Rhode Island, but flowing through Massachusetts for a short stretch just before it comes to the water-works intake, has already been discussed by Mr. Carpenter.

We have attempted a number of times to get help from the Massachusetts state authorities to control conditions in connection with these three supplies. As Mr. Goodnough has stated, the Attorney General has ruled that the public water supply laws in Massachusetts are so worded that they apply only to supplies within the State.

There should be a considerable community of interest between Massachusetts and Rhode Island. The drainage of the entire southeasterly section of Massachusetts flows through Rhode Island, and the ultimate outlet of these streams, together with the sewage and industrial wastes discharged into them, is through Narragansett Bay. In Rhode Island we are strenuously attempting to control the pollution of our rivers and tidal waters. Massachusetts should be interested in this problem because its

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†Chemist and Sanitary Engineer, R. I. State Board of Health, Providence, R. I.

wastes help to pollute these streams. On the other hand, the major part of the population of Rhode Island is concentrated in the cities and towns in the northerly part of the State, and in numerous places this population has overflowed the state line into Massachusetts. Some of these overflow villages are already supplied with water from the water works of the adjoining communities in Rhode Island. Furthermore, it looks very much as though additional water for at least some of these supplies must be taken from Massachusetts sources.

It looks to me as if close coöperation between Massachusetts and Rhode Island in all matters relating to the water supply and the disposal of sewage and industrial wastes in these contiguous thickly settled areas would be of considerable mutual benefit.

CROSS-CONNECTIONS IN CONNECTICUT.

BY WARREN J. SCOTT.*

[*Read September 13, 1927.*]

The question of cross-connections between potable water supplies and impure supplies is one that is causing increased concern to health authorities and water-works men. This is due mainly to the mounting number of deaths and epidemics of sickness traceable to the pollution of water supplies through such cross-connections. The Committee on Cross-Connections of the Conference of State Sanitary Engineers compiled, in 1926, a list of epidemics of typhoid or other water-borne diseases, attributed to cross-connections. Statistical records of the epidemics were unavailable in many cases, but the figures obtained showed a total of 1 664 cases of typhoid fever with 123 deaths and of 3 155 cases of other intestinal disorders. Polluted water, pumped into public supply mains through auxiliary intakes or by-passes, used at times of shortage or other emergency, accounted for a total of 5 088 cases of typhoid fever, with 103 deaths, and for about 8 000 cases of other intestinal disorders.

Another fact that has been borne home to water-works officials is the tendency of the courts in recent damage suits to place increasing responsibility upon the water-works owners to eliminate dangerous cross-connections. The American Water Works Association has already gone on record as opposed to cross-connections of any form, and a committee of this association is now at work on a study of the problem.

One fact that is agreed upon by all interested persons is that unprotected cross-connections with impure water supplies, auxiliary intakes and by-passes are dangerous. The question which has enlivened many water-works meetings is whether double check-valves, installed under the best conditions, are sufficient protection. On the one side are presented arguments that any mechanical device of this sort may fail, with disastrous results; and on the other side it is contended that in actual practice the danger is negligible, provided double check-valves are properly installed and suitably maintained and supervised, and also that a great economic saving results from the use of these installations.

It is intended to review the situation in Connecticut which has recently passed through a very interesting development along this line.

Adoption of Regulations. The Connecticut State Department of Health had for many years recommended to local officials that steps be taken to prohibit cross-connections, but no state action had been taken. Hartford and Stamford, on their own initiative, abolished all cross-connections with their systems. Finally in May, 1926, the Public Health

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Council of the State Department of Health held a public hearing at the State Capitol to discuss proposed sanitary-code regulations pertaining to cross-connections. Subsequently, in July of the same year, a second public hearing was held, and on July 12, 1926, state sanitary-code regulations were adopted. These public hearings were of tremendous value in eliminating misunderstandings. The manufacturers of the State and representatives of insurance interests discussed the situation from their angles but demonstrated their desire to coöperate in every way necessary for the protection of the public health. The attitude of the manufacturers toward the later enforcement of the regulations was splendid. Connecticut is a manufacturing State, and the number of cross-connections existing was very large. The problem was very much simplified by the coöperation of the manufacturers, and it is with pride that we can state that in not more than two or three instances was any objection manifested toward the carrying out of the regulations, although the expenditures involved ran into hundreds of thousands of dollars.

The regulations which were finally adopted include requirements as to the quality of water supplied for domestic purposes in industrial plants, and read as follows:

Reg. 118. After December 31, 1926, no physical connection between the distribution system of a public potable water supply and that of any other water supply shall be permitted, unless such other water supply is of safe, sanitary quality and the interconnection of both supplies is approved by the State Department of Health.

No officer, board, corporation or other person or group of persons, owning or having the management or control of any potable water supply furnished to any municipality or water district, shall supply water to any person, firm, or corporation who maintains such connection.

Provided: That where such physical connections exist on December 31, 1926, and include two gate valves with indicator posts, two check valves of a design approved by the State Department of Health with drip cocks and gages for testing, all located in a vault of water-tight construction readily accessible for periodic inspection, the date of discontinuance may be temporarily extended, with the permission of the State Department of Health.

PERMISSIBLE ARRANGEMENTS WHERE DUAL SUPPLIES ARE USED.

Reg. 119. If a public potable water supply is used as an auxiliary supply delivered to a tank, which tank is also supplied with water from a source with which cross-connections are not permitted by Regulation 118, such tank shall be open to atmospheric pressure and the potable water supply shall be supplied above the maximum level of water in the tank. The tank overflow shall be of adequate size to fix definitely the maximum level.

If the auxiliary water supply is secured from a tank supplied only from a potable water supply and directly connected to a potable water supply, such tank shall be so constructed as to avoid any possible contamination of the water in the tank.

NON-POTABLE WATER TO BE RENDERED UNAVAILABLE FOR DRINKING.

Reg. 120. No water supply shall be used or rendered available for drinking and for other personal or domestic purposes in any industrial plant, unless such supply is

of safe, sanitary quality approved by the State Department of Health. If a water supply for industrial or fire-protection purposes is obtained entirely or in part from a source not approved for drinking purposes, this supply shall be distributed through an independent piping system having no connection with the systems for drinking and for other domestic use.

The provision whereby installations of double check-valves of approved type with adequate facilities for testing, which were in existence on December 31, 1926, are temporarily permitted with the approval of the State Department of Health, was inserted because it was felt that double check-valves of latest improved type should be given a fair try-out. The length of extension of time granted will depend on the investigations the Department is now making as to the efficiency of these valves. The results of these investigations to date are herein discussed.

The Work of Elimination. Immediately upon the passage of the regulations, all water officials in the State were advised of the fact and were asked to investigate all possible cross-connections with their systems and to notify all owners of such connections in regard to the regulations. This was done very assiduously in almost all cases. At the same time the Manufacturers' Association notified its membership, and many manufacturers were approached by their insurance representatives who, of course, wished their fire-protection systems to conform to the state regulations. The result was that requests for inspections commenced to pour into the office of the State Department of Health. These requests were complied with as rapidly as possible. They were of varied nature. Some water officials wished one of our engineers to accompany them on their tours of inspection; some concerns wished approval of secondary supplies as potable; others wished to know whether or not the regulations affected them; some wanted advice as to how to avoid the use of secondary supplies; and some wanted more data on double check-valves. With the coöperation of water officials and manufacturers, all conditions were investigated, and, shortly after the time set, all cross-connections in the State were eliminated, or protected by double check-valves under permit.

The work was, of course, handled differently by various local officials. As already stated, in some instances a representative of the State Department of Health accompanied the local officials on tours of inspection. Some water departments made very exhaustive surveys on their own initiative. Mr. Minor of the New Haven Water Company had sketches prepared by one of his engineers showing the cross-connections existing with over a hundred private systems and went into the matter carefully with the persons concerned. Other officials simply notified their customers and left the necessary changes to them. A large number of plants was entirely covered by inspections of our department, made at the request of the manufacturers. The State Department of Health, of course, endeavored to coöperate in every way with the local officials.

The location of all cross-connections presents a difficult problem.

Some water-works officials prepared printed notices regarding the regulations, which were sent to all their customers. Some small connections which had been overlooked were discovered by the customers and were reported to the officials. It was felt that by notifying the customers the responsibility was transferred to the person maintaining the connection. However, in the case of industrial plants of any size, a visit was always made by the water department or the State Department of Health, and follow-up inspections were made where changes were necessary.

The points which seem worth while as a result of our experience are discussed as follows:

Double Check-Valves. The Connecticut State Department of Health has in no case recommended double check-valves and in every instance has strongly urged that absolute separation be provided between potable and non-potable supplies. Manufacturers were advised that if they installed double check-valves, they did so with the distinct understanding that these valves might be ordered removed in the near future, if pending investigations furnished proof as to non-reliability of the best check valves available. Notwithstanding, many check valves were installed. A large number of installations were already in. Some manufacturers contended that their investment for absolute separation would be so great that, even if double check-valves were allowed only for a year or two, the investment would not be greater than the interest on the larger outlay. Others wished to delay large changes, pending changes in plant lay-outs. The insurance requirements in some cases undoubtedly decided manufacturers to try out double check-valves. One manufacturer stated that he would not install double check-valves unless we gave him a five-year guarantee. We refused the guarantee and he decided to cut off the auxiliary supply and pay a higher insurance rate.

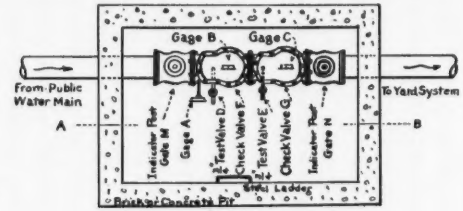
The regulations state that temporarily double check-valves of approved type with indicator posts, drip cocks and gages for testing, all located in a vault of water-tight construction, may be provided. The accompanying figure shows the lay-out suggested by the Department. As to the types of approved check-valves, the Department approved the so-called special Factory Mutual valves and the so-called Rice or Underwood valves. The special F.M. valves are iron-body valves and have flat rubber facings on the clappers. The Rice or Underwood valves are practically the same as those designed by Mr. C. D. Rice of the Underwood Typewriter Company, Hartford, at the time when Hartford was considering absolute separation, which was later adopted. They are all-bronze valves and the facings are of hard rubber so made that a round surface comes in contact with the seat, to make a hair-line contact. The Associated Factory Mutual Fire Insurance Companies have recommended the all-bronze valves for adoption by their risks, although they have advised their clients that these valves might later be ordered out. These valves are all built so that the covers can be readily removed and the clappers and seats inspected.

NORMAL CONDITION OF VALVES

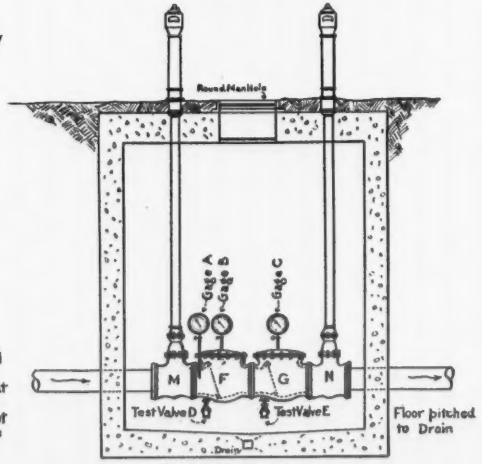
OPEN
Gates M-N

SHUT
Test Valves D-E

About once a year inspect check valves and thoroughly clean whole interior



PLAN



SECTION THROUGH A-B

Size of Pit etc will vary with different sizes of valves and local conditions but in general the Pit should be not smaller than about 4'-6" x 8' x 6' deep
Pit to be water tight where in wet soil and properly drained where in dry soil

METHOD OF TESTING

Open test valve D to blow out any sediment that may have accumulated in test valve or connecting pipe and then close.

Close gate M and open test valve D If pressure falls at gage A & pressure at gage B holds after decreasing slightly, check F is tight.

While test valve D remains open and pressure at gage A stands at zero, open test valve E. If pressure at gage B falls to zero and flow from test valve E ceases, check G is tight.

CAUTION - Immediately at close of test see that gates M and N are open. It is important that the protection be promptly restored.

FIRE SERVICE CONNECTION USING TWO CHECK VALVES

- OF APPROVED TYPE -

CONNECTICUT STATE DEPARTMENT OF HEALTH

OCT. 1926 F.A.A.

Not to scale

SCOTT.

In the case of every double check-valve installation, a written application form was filled in and submitted by the owner to the State Department of Health. A temporary permit was then forwarded after an engineer from the Department had tested the installation, and a duplicate copy of each permit was sent to the water department concerned. It is felt that this permit had a two-fold effect. It definitely informed the holder that the arrangement is temporary, in case changes are later necessary, and it placed the location of each installation on the records of the State Department of Health and the water department.

Some exceptions to the literal interpretation of the wording of the regulations have been advisable. In some cases, one indicator post valve was in place outside of the pit containing the other valves and appurtenances. This did not exactly comply with the regulations and if the valve leaked, it would not be readily accessible for repairs. However, so many installations of this nature existed, that they were allowed, as this was not felt to be a serious drawback. In many locations the installation of indicator post valves would be next to impossible without very extensive changes. It was therefore decided that outside screw and yoke valves with rising stems would be acceptable. These were either marked with the direction to open or placarded so that any lay inspector could readily tell which way to open. In no cases were the city gate valves allowed in place of indicator gate valves accompanying the installation. This arrangement leaves an element of uncertainty and renders the test much more bothersome. Where double check-valves exist, they should be provided with every facility for ready testing and ready inspection.

Difficulty is encountered in cases where pits are not properly drained. In these, the drip cocks are submerged in water and consequently are not subject to observation. Either the pits must be of water-tight construction or a drain must be provided or an injector, or some other device, installed to pump out accumulations of water.

The installations are tested by closing the gate on the city side and opening the drip between the gate and the first check. If the pressure falls to zero, the drip ceases and the pressure between the two checks holds; perhaps after a slight drop, when the clapper closes, the first check is tight. Complications sometimes arise because of a leaky gate, but a leak in a gate can be detected. The drip between the two checks is later opened, and any possible leakage of the second check is noted by observing whether, after the pressure between the checks is lowered and the drip cock closed, any subsequent increase in pressure takes place; or in some cases all the water between the checks is drained out and if the drip ceases, the second check is tight. It is important that the gate valve be opened again after the test is made, so as to restore fire protection in the mill.

It was surprising to find a number of mills where double check-valves existed, which had drinking water lines for the mill taken off inside the check valves, so that while the checks protected the public mains, the mill

drinking lines were subject to contamination from polluted water. Changes, of course, had to be made to correct this.

Results of Check-Valve Survey to Date. There are now in Connecticut 100 separate factories, a few of which are under the same ownership, maintaining 162 double check-valve installations, operating under temporary permits. Of these, 49, or approximately 30 per cent., are of the all-bronze type. These check-valves are being tested at intervals of about two months by engineers from the State Department of Health. Previous to the inauguration of periodic testing, 101 tests were made of various installations, most of which were iron-body valves, but some were of the newer type. Of these tests, 90 were tight, 9 were found leaking in the outside valve, and 2 in the inside valve. One of the leaking installations was an all-bronze one where our engineer found that a newspaper, packed around the new clapper when shipped, had not been removed. This was, of course, an exceptional condition but is an indication of the frailty of all of us humans as well as of our mechanical devices.

Since January, 1927, periodic tests have been carried out. Of 167 tests of the 49 bronze installations up to August 31, 1927, no cases were found of both checks leaking and only one case, or 0.6 per cent., was encountered where one check (the outside one) leaked. Of 380 tests of the other approved check-valve installations, 7 were found with a leaking outside check and 2 were found where the inside check leaked. In other words, 2.4 per cent. of the 380 tests showed one leaking valve. The number of tests made does not include a recent test of one installation where both valves were found to be leaking, but upon opening up the valves for inspection, it was discovered that an old fire-service installation had not been provided with rubber facings, so that the valves were not of approved type. This condition is to be corrected immediately. This calls attention to the necessity for immediate inspection of leaking installations by either the water-works or health department inspectors.

It will be seen that the odds are considerably in favor of the newer type valves. On the other hand, it must be remembered that the bronze installations are all new and have an advantage in point of age. In considering the good results obtained in these tests, it is also to be borne in mind that practically all the installations were overhauled at the time the regulations went into effect. This is, of course, what the advocates of double check-valves always contend: that the valves must be properly maintained; but the exceptional precautions in most of these cases must be considered in comparing these results with those obtained elsewhere.

In fairness to the efficiency of double check-valves, it must be admitted that errors can easily be made in testing, so that apparent leaks may not be leaks at all. Practically all of our tests were made, however, by experienced engineers who carefully investigated each apparent leaky condition, and it is felt the results are unusually reliable. Whenever a leak was

found, the valve was opened and inspected. In the majority of cases, very small particles of grit were the cause of the trouble. Leaky gate valves complicate testing, as do stoppages of drip cocks, low pressures, piping unwisely taken off the main at the installation, or faulty test gages. It is fortunate, however, that any error will, in almost all instances, operate against the check valves; this is far more desirable than the reverse condition.

It seems important that the inspector of check-valves be intelligent and well trained. On most of the tests made by representatives of the State Department of Health, the water department also sends along a man to observe the tests. Should check-valves be continued in use, the work of testing will undoubtedly have to be passed on to the water departments, and it is possible that arrangements could be made whereby tests could be made jointly by the insurance engineer and the water-department inspector. This would save bother to the owner of the cross-connection and, from the insurance company standpoint, would be an additional check on the opening of gate valves after testing. It does not seem wise to pass all of the testing on to the insurance interests, and, in fact, many insurance companies make infrequent tests.

Kinds of Connections. In general, the kinds of cross-connections encountered fall into five different classes: (*a*) fire service; (*b*) industrial use; (*c*) boiler feed; (*d*) pump priming, (*e*) auxiliary drinking water.

Probably 95 per cent. of the double check-valve installations were on fire-service lines. Of course, a large number of cross-connections on fire-service lines was entirely eliminated as a result of the regulations, whereas, with the exception of two or three industrial lines, provided with check-valves, and a few approved auxiliary drinking supplies of good quality, all of the connections belonging to other classes were removed. The following remarks pertain to the various types of cross-connections:

a. Fire Service. Many concerns were obliged to construct elevated tanks to provide an auxiliary supply for sprinkler protection. Others installed tanks in the ground filled with city water, with pumps drawing suction from the tanks. If the fire system or the tanks receive other than potable water, the city water must enter the tanks above the overflow. The tanks must be of tight construction and covered. Some mills increased their city protection by additional connections. Several plants separated their fire-pump system, pumping only to hose connections at the pump or separate hydrants in the mill yard.

In four small communities, arrangements existed whereby polluted water could be pumped into drinking-water mains in case of emergency from fire. Rather extensive changes were necessary to do away with this extremely hazardous condition.

b. Industrial Use. In many places auxiliary water is used for mill purposes. Plants using water for cooling frequently found the city water too warm in the summer, necessitating the use of well water. At com-

paratively small expense, separate piping was installed in many mills. In some large plants either the city water or auxiliary water is seldom used. Pipe connections were broken and sealed. If it becomes necessary to change over, the water company will be notified and the other supply disconnected, so that no physical connection will exist between the two systems. In the case of small connections, it is sometimes possible to bring the two supplies together and to arrange the piping so that either can be connected to the mill line by a swing joint. This can be done with an elbow and unions, so that either supply can be used, but both could not be used at once. Many plants made use of tanks with the city water entering above the overflow, so that either of two supplies can be used for mill purposes without direct connection.

c. Boiler Feed. In a great many factories, it is felt necessary to provide two independent supplies for boiler feed. In some cases, the swing connection has been used, as already described. Other plants installed duplicate pumping outfits for pumping either city or other water. The boiler connection is frequently overlooked in factory lay-outs and should be checked up.

d. Pump Priming. One of the most frequently neglected connections is the pump-priming connection. Where fire pumps are retained or mill pumps are used, they are frequently primed with city water against which pressure may be developed. Usually the simplest method of removing this connection is by the construction of a small storage tank filled from above with city water and controlled by a float valve. Only a slight elevation above the pump is necessary. The fire underwriters require a tank of one half the capacity of the pump in g.p.m. That is, a 1 000 g.p.m. fire pump would require a 500-gal. tank, which corresponds to a size of only about 4 ft. on a side.

e. Auxiliary Drinking Water. The regulations provide against interconnection with the public supply unless the auxiliary supply is approved by the State Department of Health. Many of these auxiliary supplies, particularly well-water supplies, have been used for drinking purposes in mills for many years.

In general, it is wise to separate auxiliary supplies; this leaves two separate systems to deal with, but separation was not required by the State Department of Health if the auxiliary supply was potable.

A large number of auxiliary water supplies were inspected, analyzed, and passed on by the State Department of Health for interconnection with public water supplies. The types of these supplies were as follows:

1. Surface supplies from poor watersheds. These naturally were not approved.

2. Surface supplies from very clean watersheds. Even in such cases the supplies were not approved owing to the danger of chance contamination. In two instances, however, where large auxiliary supplies were derived from excellent watersheds with a fair amount of storage, the use

of the water with chlorination was approved. Both of these drainage areas were owned mostly by the manufacturing concerns, and the supplies were on a par with the average run of our present public supplies.

3. Tanks filled with rain water. The Department did not approve such tanks for direct interconnection with the city supply. It was felt that the amount of dirt, bird droppings, etc., washed into a tank and stored would not be acceptable. Large numbers of bacteria, even though not of human origin, are washed into these tanks and are likely to multiply rapidly. Moreover, the amount of water saved is small. Assume an annual rainfall of 40 in., and that half this amount is secured. Twenty inches on a roof 100 ft. square amount only to about 125 000 gal. per year. Although sometimes requiring considerable expense for re-piping, these tanks can frequently be pumped out and filled with city water only.

4. Ground-water supplies are perhaps the most troublesome to deal with. Some, of course, are obviously unsafe. Others are from deep wells and show excellent bacteriological analyses but slightly abnormal chemical analyses. In many cases, there are no readily apparent sources of pollution, but the abnormal results cast some suspicion on the quality of the water. Where the results were very abnormal, we could not, of course, approve the supplies. Where the results were only very slightly abnormal, it was recommended that separation from the city supply be effected and that the water be used in the mill for drinking, only if it be frequently analyzed. The situation becomes further complicated by the strong protests made by mill employees against giving up the well water. Its physical character is frequently far superior to that of the city water.

5. *Tanks filled with city water.* The underground tank filled with city water should be inspected as carefully as possible to determine that it is water-tight. Some of these tanks are open to the decided objection that their overflow or draw-off is connected directly to sewers. Especially where the sewers receive surface water, there is the possibility that at times of heavy run-off, the sewer may back up into the tank and pollute the tank water. This can sometimes be obviated by constructing the tank overflow to discharge into a basin which would overflow onto the ground before getting back into the tank, provided the elevations are right. In other cases, it may be necessary to plug the draw-off or raise the overflow above the ground level.

Conclusions.

It is felt that the results accomplished in Connecticut with cross-connections have been very much worth while. The great majority of cross-connections has been eliminated. The results in such manufacturing cities as Bristol and New Britain, where only one plant in each place has resorted to double check-valves, point to the efficacy of the educational campaign and the coöperative efforts of the manufacturers. The change

has been accomplished without the necessity for drastic action on the part of the State Health Department in any instance.

No new double check-valve installations are allowed. A considerable percentage of the double check-valves left are of the best type yet designed and have so far worked as satisfactorily as can be hoped for with any mechanical device. The other types of valves have also shown up to very fair advantage. They all will be kept under careful surveillance if continued in use.

There is no question but that complete separation is the only entirely satisfactory procedure. In considering the economic reasons for the use of double check-valves, it would seem that the most important consideration is that of fire hazard. Except possibly in the case of fire-protection connections, or certain unusual circumstances, all cross-connections with non-potable supplies should, without question, be entirely eliminated. The relative danger of the use of double check-valves on fire-protection lines as against the economic value of property must be passed on by the authorities in each community and State from the standpoint of health first, and the economic value of property second.

Certainly, with the precautions that are being taken to protect our watersheds and treat our supplies, and with the existing safeguards that nature has provided by storage and dilution, there is no direct menace comparable to pumping a "slug" of polluted water into the mains that supply people with drinking water.

Progress Report of Committee on Cross-Connections.

Robert Spurr Weston.* Gentlemen, the Committee on Cross-Connections has held four meetings, one of which was at the Laboratory of the Inspection Department of the Factory Mutual Fire Insurance Companies, where the improved double check-valve was inspected and methods of testing were demonstrated by Mr. Lacount and also by Mr. Mowry.

It was realized early in the work of the Committee that it would be impossible for the Committee to make a report at this meeting. The status of the work is as follows: a report has been drafted embodying the points upon which all of the members are in agreement. The main point of lack of agreement is regarding the double check-valve — whether it ought to be permitted and, if so, how permitted; whether it shall be condemned or be given a period of trial. The Committee expects to present a full report at the next annual meeting.

Discussion.

Mr. Weston. I would be very glad to entertain any discussion on the part of members regarding this important subject. You may know that

*Consulting Engineer, Boston, Mass.

various States have taken action regarding it. The last one noted was the State of New Jersey, where Mr. Croft, the Chief Engineer of the State Department of Health, took the position that no cross-connections ought to be permitted except during a period of transition ending in 1928. That position was opposed by the manufacturers of New Jersey, who said that the period of permission ought not to end in 1928 but should be continued indefinitely, provided the valves were properly inspected and properly designed.

The *Engineering News-Record*, in an editorial, stated that the ratification of double check-valves in cross-connections, while better than single check-valves, simply divided the chance by two. A member of our Committee thinks that the law of probabilities gives relatively far more protective value to two check-valves than to one, — that is, far more than the two-to-one ratio.

Questions like these the Committee is discussing now. I cannot speak for the whole Committee on any phase of this matter, because the members have not really tried to see how far we can agree on some of them; therefore, it would be ill-fitting to express an opinion either for the Committee or for myself at this time. But the Committee would be more than pleased to have the members express their opinions, that we may be able to get a cross-section of the Association's opinion before the report is made.

CHARLES W. SHERMAN.* I believe that the double check-valve very much more than cuts the risk in half as compared with the single valve, assuming that they are of the same type and equally good as mechanical appliances. Probably the installation of a double-check would mean not less than cutting the risk to one-fourth of that with a single-check.

The great objection in my mind to a double-check is the objection to depending upon any mechanical apparatus for protecting public health. It is efficient in proportion to human inspection and upkeep. In too many places there is a tendency to let such things go, and to assume that they are going to work all right indefinitely. I know there are water departments where such apparatus would receive no attention until somebody from outside came around and looked into it; and in places like that the double-check, or any other kind of mechanical apparatus, has no place.

If a suitable inspection routine under proper authority can be arranged for and carried out properly at suitable intervals, I believe the double-check has a very valuable place, although I believe that the desirable thing is to have no cross-connections, if this can be accomplished without too great hardship and without too great expense. Absolute separation is what we want, and what we should work for wherever it is possible. I do not feel, however, that we are yet ready to say that the double-check should be eliminated entirely *if* proper inspection can be kept up.

HENRY R. BUCK.† At one time there was a recommendation that there

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†Of Buck and Sheldon, Inc., Engineers, Hartford, Conn.

be an alarm placed between the two check-valves, so that if the mill pumps operated, the pressure rose on the mill side, and the inside check-valve leaked, there would be a gong rung electrically or some definite record made of that increased pressure between the two check-valves. Has anything of that kind been tried out, and what is the experience with it?

CHARLES W. MOWRY.* The use of alarm devices between the checks was considered in Hartford nineteen years ago when double-checks were first installed. The trouble was that, while the alarm would be given under the conditions which you have mentioned, it would not be given if the outside check were leaking nor under the far more serious condition of both valves leaking, because then there would be no material increase in pressure between the checks, and the water would flow out into the main without giving the alarm. It is to be remembered, however, that the fire pump is never run or never should be run on the system with the city valves open except in time of fire. The test of the fire pump during the summer time is, or should be, made with the city gate valve closed. It was not felt on the whole that the alarm was really worth the extra cost and trouble of maintenance.

To refer to the matter of inspection which Mr. Sherman mentioned, I think New Bedford is an excellent example of what can be done on check-valve inspection and maintenance work. Mr. Taylor has developed practice which is well systematized. Four times a year the valves are tested, and once every year the valves are thoroughly cleaned inside, the interiors are scraped, and any rubber facings that need renewing are replaced. That is one example, and Connecticut under the present conditions is another. The State Department of Health is certainly giving very careful supervision to the double check-valves in Connecticut. Speaking for the Factory Mutual Companies, I can say that we have coöperated with Mr. Scott to the best of our ability in getting the connections fixed up in accordance with the requirements of the State Department of Health, and also in maintaining them in good, tight condition.

A third point has been mentioned by Mr. Weston, namely, the probability of two checks leaking at the same time. When I read editorially in *Engineering News-Record* that two checks merely halved the danger, I looked up in my old algebra the laws of probability and found that when two independent events are equally likely to happen, the chance that the two may happen simultaneously is the product of the two separate probabilities. In other words, let us assume that one check valve of a pair in series might leak once in 100 days; and let us assume that the other check valve also might leak once in 100 days. Now, the probability that the two will leak together is not once in 200 days, as this editorial said, but is 1/100 times 1/100, or once in 10 000 days. That is the algebraic law. Of course checks do not work exactly according to that law, but that would be the probability under the assumed conditions.

*Of Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

There is still another thing which has been overlooked. Before trouble can occur, a third independent event must happen, even if both checks may be leaking, and that is that the fire pump must be operating at the same time. If you know how many times the pump is operated in a year for a fire and multiply that fraction by the other two factors, you get some idea of the remoteness of the trouble. If the pump should be run for a fire once a year and if we make the same assumptions regarding the check-valves as we did before, the probability of both checks leaking simultaneously with the operation of the fire pump would be $\frac{1}{100} \times \frac{1}{100} \times \frac{1}{365}$, or once in 3 650 000 days, or once in ten thousand years. You will see, therefore, that the chance of trouble with any one connection is reduced practically to the vanishing point.

STEPHEN H. TAYLOR.* As a member of the Committee I do not know that I should say very much until the report comes out.

I might cite New Bedford as a case where we have some sixty-odd connections, and the only source of secondary supply for the manufacturing plants is salt water. We feel that by proper inspection we have eliminated pretty well the danger of any pollution due to these cross-connections with fire pumps using salt water. We are not without experience in the matter. In the old days of the single check we had a case where salt water was pumped back into the city main from a mill fire pump, due to a defective check. In those days the single old-type iron check was buried and forgotten until something happened; but present practice is entirely different. The checks are of greatly improved design and construction. They are placed in pits accessible for inspection. We now test the connections thoroughly at least four times a year, and about once a year take the valves apart and clean them and make sure they are all right. A short time ago we took out practically all the rubber faces from the valves, whether they appeared to be badly worn or not, and replaced them with new ones. It is not a very expensive thing. The expense of inspection and repair is passed on to the owner of the property on which these checks are located.

I think we can agree pretty well on very nearly all the questions which are to be considered. But I do think that in some cases where the only satisfactory source of secondary supply is from a source not too badly polluted something can be done so that it can be used under proper safeguards, such as using the best type of double check-valves, properly installed and inspected. A great deal of emphasis should be laid on proper inspection and care.

MR. SCOTT. In regard to figuring the probability of both checks leaking at the same time, I wonder if Mr. Mowry has considered that in the great majority of instances the leak occurs in the check valve towards the city side. It does not seem to be a 50-50 proposition between the two valves; it is much more likely to occur in the check on the city side.

*Superintendent of Water Works, New Bedford, Mass.

MR. MOWRY. I did not figure the actual probability; I merely gave an example as to how the rule would be applied. I do not know what the actual probability is, but it is true, as Mr. Scott said, that the valve on the city side is the one which is most frequently found leaking. Hence, the two probability factors would not be equal. They would be more nearly in the ratio of 1/100 times 1/300.

The reason why the outside check is the one usually found leaking, as we have analyzed it, is because all water contains a certain amount of sediment, and there is a very slight continuous flow of water into a yard system to make up the leakage at lead joints and hydrant drips, and at the stuffing boxes of valves. This continuous slight flow holds the check-valve clappers off their seats a very small amount, and this narrow crevice really acts somewhat as a filter, so that any particle of foreign material would naturally be trapped under the outside check-valve clapper first. This is the principal reason why the outside check is the one which is usually found leaking. It must be remembered, however, that in case of fire the flow of water to supply sprinklers or hose streams would tend to wash the material from this seat ring.

HARRY A. BURNHAM.* I would like to ask Mr. Scott if, when he makes tests, he flushes the valve first.

MR. SCOTT. The procedure we follow is that if we test a valve and find what appears to be very slight leakage, we repeat the test as a further check. We do this because it is possible under quiescent conditions that a small particle of grit might rest on the seat but would be flushed out as soon as normal conditions were restored and any flow of water passed the check. Therefore, we consider that all the leaks we have found are real leaks.

M. N. BAKER.† In regard to the situation in New Jersey, some two or three years ago the New Jersey State Department of Health passed an order that all cross-connections must be eliminated by a certain date, except that where there were double check-valves more time was given, and that time was extended on request, to December 31 of this year.

About May of this year, Mr. Croft, chief of the engineering bureau of the department, brought the matter up again and proposed the elimination of not only cross-connections but also of all manner of physical connections with possibly dangerous water supplies, emergency intakes and also by-passes at purification works. This was in line with resolutions adopted by the State Sanitary Engineers (engineers of state boards of health and the U. S. Public Health Service) and also adopted by a technical section of American Water Works Association. The proposed action in New Jersey now takes a different form in that instead of being a resolution it will, if adopted, become a part of the State Sanitary Code.

The Manufacturers' Association in New Jersey, as Mr. Weston has stated, has tried to get the prohibition stricken out relating to double check-

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†Associate Editor, *Engineering News-Record*, New York City.

valves, and, if I remember rightly, the amendment was scheduled to come up in Trenton today.

As to the application of the law of probabilities to leaking check-valves, a stronger case could be made by taking 1 000 instead of 100 as the frequency interval of leaks; at any given works on any day, there may be a leak in one or the other and possibly in both check-valves. It may occur, as has often been said in these discussions, the day after an inspection, and the most that has been proposed is inspection every two months, while inspection three or four times a year is the rule at New Bedford, and Mr. Sherman has stated that in many water works, in his opinion, there would be no inspection at all so far as the local water department was concerned.

CHARLES D. HOWARD.* I would like to ask Mr. Scott if he has any opinion to express in regard to the relative efficiency of check-valves in a vertical position as compared to those in a horizontal position.

MR. SCOTT. I would never recommend that check-valves be installed in a vertical position. We have had a couple of installations that were on a slant from the horizontal, and we have had a lot of trouble with them.

MR. MOWRY. Wherever the pipe slopes downward so that the clappers would tend to hang off the seats, we have put in the necessary bends so that the valves would be horizontal, because the clappers hang nearly vertical. If the pipe should slope upward in the direction of flow, the clappers would press on the seats slightly more than normal.

GEORGE F. MERRILL (Ware, Mass.). There is one phase of the check-valve situation that has occurred to me. I found that in my town an arrangement had been made with one manufacturing company which has a fire pump so that if at any time the chief of the fire department thought it was desirable to increase the water supply for fire service, the clappers would be taken out of the check-valves and the company would pump directly into the system. This might be called "a slight leak" in a check-valve.

As to the leakage of check-valves, there is one feature that enters in quite materially, namely, the distance that the pump is located from the check-valves. In some cases we have a pump that is several hundred feet away from the check-valves, and if water is being used in the system, fresh water going in from the mains, it would seem to me that the flow would counteract the effect of a possible slight leak. Considerable water would have to be displaced before any polluted water would pass through the check-valves. When the pump connection is very near the check-valves, I think the danger from leakage would be very serious, because there must be some pulsation in the valve checks, and, even with double-checks, a small amount of water would escape.

J. E. GIBSON.† I am not going to talk about cross-connections between polluted water supplies and the city's supply, but rather cross-connections

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†Manager, Commissioners of Public Works, Charleston, S. C.

between the ammonia system of an ice-making plant and the city's water supply. Just about eight months ago one of our ice-making plants changed over from steam to electric power. They were making what is locally known as raw-water ice; that is, they make the ice directly from the city water without distillation. In changing over to the electric supply they, of course, abandoned their steam plant, and therefore had no hot water for heating the cans so as to make the ice slip out of the cans readily. I understand that it is good practice in the electrically operated plants to use the ammonia coming from the compressor to heat water for the purpose of melting the ice out of the cans. The heater is of the coil type, with an iron coil substituted for the copper coil of a feed-water heater.

Now comes the problem of probabilities: the combination of two separate and distinct events happening simultaneously. Our central electric plant had a breakdown in which one of the machines went out, so that the entire load could not be carried. Manufacturing consumers were canvassed to see who could best be shut off. The ice plant could readily be shut down because there was another plant owned by the same company which could produce all of the ice then required. In a coöperative spirit, the plant in question was shut down for a period of about ten days. After service had been restored and the ice plant had been operating a couple of hours we received word from one of our consumers near the plant, asking us when we had begun to supply household ammonia through the water mains. We could hardly believe the statement; nevertheless, we got our men on the job. About the same time the superintendent of the ice plant called me up, saying, "Mr. Gibson, something has happened; I don't know what, but please come up and shut the water off quick." What had happened is this, — the iron coil in the ammonia water heater had sprung a leak; the ammonia gas had combined with the water and had begun to work back through a check-valve that was not seating properly and had got into the main. We had a pretty strong household ammonia over about one-tenth sq. mile of our territory, and some of the ammonia water had gone as far as three-quarters of a mile from the ice plant. We sent out word to everyone in the neighborhood as fast as we could by our own forces, and through the Police Department, to be careful of the water as it had ammonia in it, and we further relieved the situation by flushing, but it required about six or eight hours of flushing before all trace of the ammonia disappeared. This simply goes to show that any kind of a cross-connection is a poor thing to have, and — like the Irishman's recipe for railroad accidents — "absence of body is the best method."

Mr. Weston. May I just say one general word covering this whole question? We must look at it sociologically. We can minimize or obviate the direct danger of cross-connections by having none, but at the same time introducing the danger of loss of life, such as that due to a conflagration in a mill where watchmen and firemen might be killed. Now, I do not believe it is good political economy to spend a million dollars to save one

typhoid fever case in one hundred thousand people, even if, from the humanitarian standpoint, it may be well worth while. You might save the life of an Abraham Lincoln or Edison, of course. But you have to look at the possibilities practically, and cannot increase the fire hazards, in order to increase the sanitary protection, if the results promise no net saving in life. On the other hand, we cannot neglect the public health, in order to protect property.

THEODORE L. BRISTOL.* I am glad that Mr. Weston brought up this subject, because it is my opinion that the insurance people have always tried to impress you with the idea that the secondary connection is much more important than is actually the case. Probably in some cases it is of a great deal of importance, but in many cases I do not think it is required. I think it was shown in our last discussion of this matter that they charge very little more where you have one supply of water than they do if you have two supplies. They try to talk you into having two, but if you get your back up and say you won't have two you get by with it.

ARTHUR D. WESTON.† I regret that in today's discussion the legal responsibility of boards of water commissioners regarding cross-connections has not been considered. It is apparent that they have not only a moral but a legal responsibility in this matter. Available court decisions indicate that boards of water commissioners as well as water companies are responsible in cases of pollution of a water supply through negligence on the part of water-works officials. I hope that the Committee will consider this matter and that its report will be an incentive to the superintendents to investigate more carefully the conditions of all cross-connections in their municipalities. Some superintendents probably do not take enough interest in ascertaining the condition of cross-connections. I know of one case where the existence of a single check-valve was called to the attention of a water department and the suggestion made that they request the manufacturer to uncover the valve and ascertain its condition. This the manufacturer was loath to do, and it was then suggested that the water be shut off at this plant until the condition of the valve was known. A threat to shut off the water at this manufacturing plant would have resulted, no doubt, in the examination or removal of the check-valve if necessary.

MR. MOWRY. I think this is a good place to point out that the improved double check-valve arrangement does not utilize the same type of check that would be used in the ordinary commercial equipment. The special check-valve has very liberal clearances around the clapper in all positions of its travel. The clapper is rubber-faced, and the seat ring in the iron-body type of valve is of bronze and especially wide, designed particularly for its purpose. Then in addition to the superior construction, two of these valves are put in series, tested regularly and cleaned annually. You will see, therefore, that there is really no comparison between the

*President, Ansonia Water Works, Ansonia, Conn.
†State Department of Public Health, Boston, Mass.

possibility of leakage between the ordinary check-valve, which is often buried in the ground and forgotten, and a pair of special check-valves readily accessible and properly maintained.

MR. BAKER. I would like to say one word more. After all, what additional cost there is in eliminating cross-connections comes upon the consumer of the products which are being manufactured, and when it is distributed among all the consumers, if there is any additional cost it is a mere trifle. Manufacturers, ever since we have had centralized manufacturing industries, have had to look out for what they have considered to be their interests, but they have done it at a tremendous sacrifice of life from that time to this, although for various reasons, much less of late. For scores of years in England, in order that the manufacturer might make more money, small children were gotten up before daylight to go into the cotton and other mills to work, and were kept there through long and weary hours. And so in one way or another, it has been in greater or less degree ever since. Whenever anything is proposed in the interests of humanity, of life saving, better living, if it is going to increase the cost, it is always opposed by some manufacturers, although now their number is happily less.

In the case of cross-connections, as I have said, the increases in cost of manufacture, if any there be, are small indeed when they come to be distributed among the ultimate consumers,— and we, the ultimate consumers of clothing, or whatever it may be that these plants make, have to pay the bills, and I am sure that individually we are quite willing, if there is any added cost in this respect, to stand it.

I hope that our committee on cross-connections will present figures which really show what this additional cost is, and how it would affect the unit price on the total product of a few large manufacturing plants.

HENRY V. MACKSEY.* I am quite in sympathy with the demand that it should be mandatory to prevent cross-connections being made, but I fear that in order to pass such a bill the man who presents it on the Hill will find that the pressure that is brought to bear against him there will be just as strongly shown as it would be before a Board of Water Commissioners or before any city or town government. I am not satisfied to say that because a law is made forbidding anything, that it will always be observed. Many things are done now in the water-works business, as well as in others, that are contrary to law. If, however, a mill owner appreciated that he was endangering the health of the community by contaminating the water supply of his town, he would stop it immediately. If you go before the Massachusetts Legislature, or before any other legislature of New England, and show a benefit to the people as a whole the cost of which will be charged against the textile industry at this time when they are pleading poverty — and I believe honestly pleading it — your Committee will have a hard time. Still, I would like to see the effort made.

*Framingham Centre, Mass.

MR. SCOTT. I would like to say a brief word in defence of the manufacturers. I think that the manufacturers in Connecticut deserve a great deal of credit for their attitude on the whole matter. As I have already stated, we consider that our public hearings were of great value in securing a satisfactory understanding of the situation. There are a great many of our manufacturers who immediately removed all their cross-connections. The ones who have large investments to make, if they do away with the double check-valves, frankly came out and stated that if the results obtained with the newest type of check-valves were not satisfactory they were ready to go ahead and make the necessary changes. I think the whole thing can be carried out on a coöperative basis, and, judging from our experience in Connecticut, I think the manufacturers will be willing to go half-way.

CHARLES D. HOWARD.* Some fifteen years ago we sought to secure a law embodying the mandatory feature just referred to, but some of the large corporations came in and quickly put a quietus on that attempt. Possibly such an attempt today might fare differently, although I am certain there would be strong opposition, because for that matter we are finding not a few of the manufacturers objecting to making any kind of improvement in this respect. In 1913, some legislation bearing upon this point was however secured, this law being amended in 1917, so as to give the State Board of Health authority to establish rules and regulations in this connection. This law prohibits the use of any unapproved form of connection and it requires that any form of connection that may be approved by the Board shall be inspected at least twice annually.

Manufacturers have been notified that the type of connection as commonly found to exist, viz., a single cast-iron check, frequently buried in the ground, will not be tolerated, and that in lieu of absolute separation of the two systems the very least that the Board will recognize is an installation of special type double-checks placed in a suitable testing pit, with tests by the water works at least once every six months, reports of all such tests to be made to our department on special forms provided.

This means, of course, that we have been giving tacit approval to this type of connection, which, assuming there is the requisite inspection, we are inclined at this time to believe affords about as high a degree of protection as can be expected of any other device or treatment involving the human factor and designed for safeguarding the consumer against polluted water. We recognize, of course, that this does not give the same degree of safety which absolute separation would give. It has been a case of doing the best we could in actual practice and with the means at hand for alleviating a bad situation.

EDWARD A. BARRIER.† I just want to enter a protest against some remarks that have been made to indicate that it is wholly a question of dollars against public health. I think it is something more than that.

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†Vice-President, Arkwright Mutual Fire Insurance Co., Boston, Mass.

There is no question but that in our social life there are many conditions where, by prohibiting certain things, we could save a few lives. For instance, take the automobile situation. You could place a lot of restrictions on the use of automobiles and you might reduce the number of accidents. But is it wise to go too far in this direction?

Now, the organization that I am connected with has advocated the double check-valve. I hate to have anybody say that we realize that we are endangering the public health, but still are advocating this device purely from the standpoint of saving a few dollars. I am sure that the companies that I am associated with have some of the highest-minded men there are in the country, and if they advocate the secondary water supplies protected with double check-valves it is because they honestly think that this is a reasonable safeguard. It is not a positive safeguard. None of the methods that are used by the public water officials for safeguarding the water supplies are one hundred per cent. perfect. There are possibilities of failure in a great number of ways.

The only contention that we make is that the special fire-service check-valve safeguards the public water supply to as great a degree as many other measures intended to secure pure water, and it is a question of protecting not only property but lives, because there have been many serious fires where the lack of adequate fire protection has resulted in loss of life.

So that I think, concerning the whole question, a narrow view of it should not be taken. It must be remembered that there may be an honest difference of opinion, and just because we advocate special service check-valves does not indicate a purely mercenary point of view.

ELIMINATION OF ERRORS IN THE ORTHO-TOLIDIN METHOD.

BY F. R. McCRUMB.*

[*Read September 14, 1927.*]

Chlorine treatment as a means of sterilization is now being used not only in the case of drinking water but also in the treatment of swimming-pool water, sewage-plant effluents and industrial wastes. The new conditions encountered render accurate control more difficult, and if the ortho-tolidin method is to be applied some modification in the procedure is necessary. Factors that must be taken into consideration are the color, turbidity and alkalinity of the material being tested as well as the presence of certain interfering substances such as manganese, iron, and nitrites. In addition, the time of development and of duration of the ortho-tolidin color, as well as the effect of temperature and light, may vary considerably with different materials.

In an investigation carried out at the Huntington, L. I., sewage chlorination plant, Tiedeman[1] made use of the ortho-tolidin method as a means of controlling the residual chlorine concentration. Since the turbidity of the sewage interferes when Nessler tubes are used after the procedure given in "Standard Methods of Water Analysis," American Public Health Association, the tests were made in ordinary one-ounce prescription bottles as recommended by Enslow.[2] A bottle of the sewage being tested was placed in front of the standard to get the effect of the turbidity, and a bottle of plain water was placed in front of the bottle of sewage, to which ortho-tolidin had been added, to equalize the depth of liquid and glass. This is merely the Walpole principle which is used so extensively in the colorimetric determination of hydrogen ion concentrations. Tiedeman found that, although this method was satisfactory as a means of control, the results secured either with sewage or water were not consistent with results secured when the starch-iodide titration method was followed. Determinations in the bottle on clear solutions also did not compare favorably with those in Nessler tubes.

When work was taken up in our laboratory in an effort to develop a portable piece of equipment that could be used in controlling chlorination, it was realized that all the factors bearing on the problem must be studied. The comparator method was adopted. Sealed Nonsol glass ampoules, 22 mm. in diameter (20 mm. bore), were used to hold the standards, and the tests were carried out in test tubes of the same diameter and bore, graduated to hold 15 cc. Both ampoules and test tubes were provided with flat bottoms so that comparisons could be made without the comparator when feasible.

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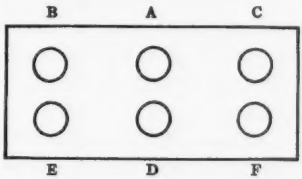
Standards were first prepared following the directions given in "Standard Methods of Water Analysis," 1925, but it was found that results secured using these standards were higher than those secured either by the starch-iodide titration method or the standard ortho-tolidin method, using Nessler tubes. In addition it was found that the standards viewed in relatively thin layers, as in the ampoules, did not approximate closely enough for comparison the shade given in the ortho-tolidin test. This was particularly true above 0.2 p.p.m. of chlorine.

It was apparent that new standards would have to be established for the comparator method. This was done by using solutions of potassium dichromate and copper sulphate. Standards were prepared for 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0 p.p.m. of chlorine, each being carefully checked by sodium thiosulphate titration and also by the standard ortho-tolidin Nessler tube method. The procedure followed in this standardization was essentially that used by Buswell and Boruff.[3] Standards prepared from light-fast dyes were equally satisfactory.

It was found that satisfactory results could be secured on turbid and colored solutions when the comparator method was followed. The comparator block used contained three slots, and a piece of etched glass was fastened on one side directly over the three slots. This glass eliminated reflections and gave more uniform comparisons. The six holes back of the slots were designated as B, A, C and E, D, F, respectively, as in the figure below:



Tests on colored or turbid solutions were made by filling three of the test tubes to the mark (15 cc.) with the liquid to be tested and placing them in the holes marked B, A, and C. To the middle tube (A) was added, by means of a graduated pipette, the necessary volume of ortho-tolidin solution, and the contents were mixed thoroughly. An ampoule of distilled water was placed in the hole marked D, and two of the chlorine standards, for example, 0.4 and 0.6, were inserted in the holes E and F. When the maximum color had developed in A, comparison was made by looking through the three pairs of tubes, holding them toward the light, with the etched glass away from the observer. The color standards were changed, if necessary, until either a direct match was obtained or the color in the test sample lay between two of the color standards.

When the concentration of free chlorine exceeded 1.0 p.p.m. the sample was diluted with chlorine-free distilled water to bring it within the range. For example, if a sample on testing showed a value greater than 1.0, a

portion was diluted with an equal volume of distilled water. If this diluted portion showed a chlorine content of 0.7 p.p.m. the original sample contained 1.4 p.p.m. Higher values required further dilution and this dilution determined the factor by which the actual reading was multiplied.

It was found that this method gave results that were accurate over the range 0.1 to 10 p.p.m. Below 0.1 p.p.m. the comparator method could not be used, due to the fact that the depth of color was insufficient, but this was not considered a limitation since the concentration of residual chlorine is rarely kept below this value.

Equally satisfactory results could be secured by means of the comparator modified to follow the method described by Michaelis[4] in which the standards were viewed through a plate of daylight or blue glass. The colors then vary from blue at 0.1 p.p.m. to yellowish green at 1.0 p.p.m.

Unfortunately, the ortho-tolidin test is not specific for free chlorine, but appears to be an oxidation reaction, and any material that has oxidizing properties should be taken into consideration. From time to time the interference of certain substances encountered in water has been investigated. The most common ones are manganese, iron, and nitrites.

We found, as reported by Hopkins[5], that manganese, whenever it was present in a valence above two, i.e., as manganic compounds or permanganate, gave a color reaction with ortho-tolidin. As would be expected, manganous compounds gave no interference, but the fact that they so readily undergo oxidation in water under a variety of conditions renders their presence a possible source of error at all times. This factor has been discussed by a number of workers, and only recently Kuhr[6] points out that this oxidation may occur even at relatively low pH values, due to the actions of certain organisms.

The effect of ferric iron was found to depend both on the actual color imparted by the iron compounds and also on the oxidizing properties. It was found that physical interference was not of practical importance unless the concentration exceeded 10 p.p.m. of ferric iron. Ferric iron did give a color with ortho-tolidin, but time was an important factor.

Using a solution of ferric sulphate and an ortho-tolidin reagent prepared from sulphuric acid to avoid the presence of the more highly colored ferric chloride, a solution containing 10 p.p.m. of ferric iron gave a color equivalent to 0.1 p.p.m. of chlorine after standing about fifteen minutes. At the end of thirty minutes it read 0.2 p.p.m. At the end of ten minutes there was no appreciable color.

Under ordinary circumstances iron should not interfere, since the time of development of the "chlorine ortho-tolidin color" is much less than that found for iron. In testing sewage the development of color is sometimes rather slow, and, if the observation is continued until the maximum color is developed, appreciable amounts of iron might cause difficulty.

Nitrites gave a color with ortho-tolidin, but the concentrations required were relatively high (5–10 p.p.m.). A possible source of error lies in the

fact that if an effluent should have a residual concentration of nitrite after chlorination this might cause confusion.

By using the same principle as was applied in the case of colored or turbid solutions, it was possible to minimize errors due to interfering substances present in the water or effluent before chlorination. This was carried out by making readings with the use of blank samples as masks. Tubes of water or effluent taken from the system immediately before chlorination, were placed in front of the chlorine color standards in the holes B and C and the material to be tested was placed behind the middle slot in the hole A. Ortho-tolidin reagent was then added to all three tubes. In the solutions in B and C, the color was due to the interfering substances; in the solution in A the color was due to both interfering substance and free chlorine. The color due to the action of the interfering substance was thus compensated for in the test, just as in the case of turbidity and color.

Some results secured by this method are given in the following table in which variable amounts of manganese and ferric iron were placed in known solutions of chlorine water. In several cases the solutions were also analyzed by the Nessler tube method.

TABLE 1.*

Manganese as Permanganate.	Chlorine added.	Chlorine found by Comparator.	Chlorine found by Nessler Tubes.	Iron as Ferric Sulphate.	Chlorine added.	Chlorine found by Comparator.
0.05	0.2	0.20	0.35	0.1	0.2	0.15
0.10	0.4	0.45	....	0.3	0.4	0.40
0.15	0.7	0.75	1.00	0.6	0.7	0.65
0.2	0.9	0.90	....	2.0	0.9	1.00
0.3	2.0	1.90	3.00	5.0	2.0	2.00

It should be borne in mind, however, that such a procedure does not take into account the changes that may occur during chlorination. If manganous or ferrous compounds were present in appreciable amounts, sufficient oxidation might take place during the chlorination as to introduce some error even when the comparator method is used.

By far the most important factor in the ortho-tolidin method is that of acidity. This was clearly recognized by the original investigators, Ellms and Hauser[7], who found that the use of a strongly acid reagent gave the best results. Practically everyone has noted the variable colors encountered when alkaline waters and effluents are being tested. This experience and the work of Clark and his co-workers[8] indicated that the color-producing substance that results when chlorine reacts with ortho-tolidin was in reality a hydrogen ion indicator, although perhaps a rather unstable one. It was apparent that, if this were true, the color resulting

*Results are stated in p.p.m.

would depend on the hydrogen ion concentration of the test portion at the time of color development.

Accordingly, an investigation of this factor was undertaken. Actual chlorine determinations were made over an extended pH range. A standard solution of chlorine was added to various buffer mixtures until the equivalent of 1.0 p.p.m. of chlorine had been added. This was done to secure the same approximate intensity of color. The ortho-tolidin reagent was then added, the mixture shaken, and after five minutes the pH determined colorimetrically, using the comparator method to compensate for the color produced by the reaction between ortho-tolidin and chlorine. Since all the chlorine was used up by the ortho-tolidin, no bleaching of the indicators was encountered. The proportions were 100 cc. of buffered chlorine solution and 1.0 cc. of ortho-tolidin reagent, the latter being prepared according to Standard Methods of Water Analysis. The results secured are given in the following table:

TABLE 2.

pH	Color.	pH	Color.
Below 1.2	Yellow.	2.8	Blue-green.
1.9	Yellow.	3.0	Green-blue.
2.2	Green-yellow.	3.5	Blue.
2.6	Yellow-green.	4.9	Muddy, fading rapidly.
2.7	Green	5.2	Muddy, fading immediately.

These data would indicate that the oxidation product is a pH indicator having a range of 2.0 to 3.5 with a color change of yellow to blue. The color designated as yellow is the one desired when making a determination of free chlorine. Strictly speaking, it is not, of course, a pure yellow but contains some green.

If para-amino-dimethyl-aniline is subjected to partial oxidation by means of bromine, a compound results that is commonly known as Wurster's red, after Wurster who with Sendtner[9] first prepared it. Such partially oxidized amines were named meriquinones, i.e., partial oxidation products, by Willstätter and Piccard.[10] The color-producing substance in the ortho-tolidin test probably belongs to this class.

In an attempt to throw some light on the nature of this reaction, ortho-tolidin was oxidized with one equivalent of chlorine in glacial acetic acid medium, and the resulting product was isolated in crystalline form. When these crystals were dissolved in water containing variable amounts of hydrochloric acid, the color produced depended entirely on the pH of the solution, and these colors corresponded in every case with those secured in the previous series of tests.

The product resulting from the oxidation with bromine, carried out in the same manner, gave essentially the same color changes, but the pH range was slightly higher, as yellow at 2.0, green at 3.5, and blue at 4.1.

These results indicated that if colors were to be secured comparable to the standards in use, the pH of the test portion at the moment of color formation must never be over 2.0 and for safety should be much lower. This accounts for Seith's[11] failure to secure satisfactory results with an ortho-tolidin reagent prepared from acetic acid. Even a test portion normal with respect to acetic acid, roughly 6.0 per cent., would have a pH of about 2.4 and the color at this point would not be satisfactory.

The point has been made that by maintaining the proper pH with a buffer mixture, it might be possible to develop a test for free chlorine based on the production of a green or blue color. While, theoretically, this is feasible, it has certain practical disadvantages in that the color is less stable at the higher pH values and that the procedure would probably lack the simplicity so essential in practice.

While alkaline waters that cause trouble are sometimes encountered, the greatest difficulty comes in testing sewage or trade wastes which are frequently rather highly buffered and require considerable acid before the proper pH is attained. Tiedeman[1] states that it requires at least 1 cc. of standard ortho-tolidin reagent to produce the proper reaction in the one-ounce bottles (or about 4 cc. per 100 cc.). We have found that the use of even a higher concentration of hydrochloric acid is advisable.

In order to secure the proper pH in the test portion during the color formation, sufficient strong acid must be added for this purpose, and the most feasible procedure is to incorporate this acid in the ortho-tolidin reagent itself. This was apparently the procedure followed by the original investigators, Ellms and Hauser[7] who recommended that the ortho-tolidin reagent be prepared to contain "one-tenth per cent. ortho-tolidin in a 10 per cent. solution of hydrochloric acid." This recommendation was followed in the earlier editions of "Standard Methods for the Examination of Water and Sewage," but later was changed to specify, "Ortho-tolidin solution. Dissolve 1 g. ortho-tolidin, melting point 129° C., in 1 liter of dilute hydrochloric acid (100 cc. concentrated acid diluted to 1 liter)."

Following the recommendations of Ellms and Hauser[7] a solution was made up to contain 0.1 per cent. of ortho-tolidin and 10 per cent. (by weight) of hydrochloric acid. The ortho-tolidin used was prepared and purified following a procedure developed in our laboratory and was of exceptional purity. It was practically white, melted at 129–130° C., and showed an average purity of 99.55 per cent. when analyzed by Palkins'[12] method. The hydrochloric acid added was accurately determined by titration with standard sodium hydroxide, using methyl red as indicator.

No difficulty was encountered in preparing such solutions and, when undisturbed, they frequently remained unchanged for as long as 48 hours. In every case, however, there finally resulted a precipitation of the dihydrochloride in the form of very thin transparent plates. The concentration of ortho-tolidin was thereby lowered appreciably.

This was apparently a case of supersaturation, and such a condition

existing in a reagent was extremely unsatisfactory. It was necessary therefore to accurately determine the maximum amount of hydrochloric acid that could be incorporated in the ortho-tolidin reagent without causing precipitation of the dihydrochloride.

A series of solubility tests was carried out in each of which 5 g. of ortho-tolidin was dissolved in a liter of dilute hydrochloric acid solution. Variable amounts of hydrochloric acid were then added to these solutions and they were then held at room temperature for four days and finally at 25 ± 1°C. for one hour. The amount of ortho-tolidin held in solution and the amount precipitated as the dihydrochloride were then determined by a modification of Palkins'[12] method.

The precipitated dihydrochloride was removed by filtration, using a Gooch crucible. The precipitate was sucked as dry as possible on the filter, redissolved in a small amount of water and reprecipitated as the dihydrochloride by adding solid sodium chloride. This precipitate was removed by filtration and washed with saturated sodium chloride solution. It was then redissolved in water, and an excess of standard, carbonate-free, sodium hydroxide was added. The precipitated ortho-tolidin was removed by filtration, washed free from excess caustic, and the filtrate and washings were titrated with standard hydrochloric acid, using methyl red as indicator.

The amount of ortho-tolidin left in solution was determined by a similar procedure. In all cases the total ortho-tolidin accounted for by analysis was practically equivalent to the amount originally used, at least within the limits of error involved in the method.

The total hydrochloric acid present was determined by diluting 5 cc. of the solution to 125–150 cc. with distilled water and titrating with M/5 sodium hydroxide solution, using methyl red as the indicator. If the sample is sufficiently dilute no precipitation of the ortho-tolidin will occur. Free hydrochloric acid was then calculated by allowing for the dihydrochloride, as previously determined.

The results secured are given in the following table:

TABLE 3.*

Hydrochloric Acid.	Ortho-tolidin.	Hydrochloric Acid.	Ortho-tolidin.
8.55	44.00	98.6	0.97
36.50	4.87	106.0	0.56
77.90	1.93	121.6	0.17
97.40	1.08	182.5	Trace

In the case where a trace is reported, no ortho-tolidin could be detected in the filtrate by the method of analysis, but addition of chlorine water gave a color.

*Results are stated in grams per liter.

As a matter of interest it should be noted that the solubility of ortho-tolidin in the solution recommended in "Standard Methods," and containing 100 cc. of concentrated (36 per cent.) hydrochloric acid per liter, is approximately 5 g.p.l.

As a further check on the solubility, a number of solutions was made up to contain one g.p.l. of ortho-tolidin and variable amounts of hydrochloric acid. These solutions were kept for some time, in some cases over six months, and in every case in which the concentration of hydrochloric acid exceeded 98 g.p.l. precipitation of the dihydrochloride occurred. Below this concentration no precipitation was noted.

Ortho-tolidin purchased on the market was also used in preparing such solutions, and it was found that when this material had a high purity, the above concentration of hydrochloric acid could not be exceeded without precipitation. Some material appeared to give contradictory results but actual analysis showed in every case that the ortho-tolidin content of the solution was less than one gram per liter. Further investigation revealed that this material contained considerable volatile matter, presumably water or some solvent.

These data indicate that the maximum amount of hydrochloric acid that can be incorporated in the ortho-tolidin reagent at $25 \pm 1°$ C. is about 98 g.p.l. Additional hydrochloric acid will lower the concentration of ortho-tolidin below one gram per liter. Variations in temperature may, however, change the solubility markedly.

In preparing such a reagent, if the concentrated acid used had a strength of 36 per cent., the amount required would be $\frac{98}{(1.183)\quad(0.36)} =$ 230 cc. Since, however, concentrated hydrochloric acid may exceed 36 per cent., there is a danger of introducing too much acid. For example, 230 cc. of 37.5 per cent. hydrochloric acid would give a concentration of 102.7 g.p.l. which would lower the concentration of ortho-tolidin to about 0.8 g.p.l.

To avoid this it was decided to prepare the ortho-tolidin reagent, using 1 g. of ortho-tolidin and 200 cc. of concentrated hydrochloric acid. If the concentrated acid varied from 35 to 37.5 per cent., the reagent would then contain from 82.46 to 89.25 g.p.l.

A satisfactory ortho-tolidin reagent is best prepared as follows: Weigh out 1 g. of ortho-tolidin and place in a small beaker. Add 10 cc. of a dilute hydrochloric acid solution prepared from 200 cc. of concentrated acid (sp. gr. 1.18–1.19) diluted to 750 cc. with distilled water. Macerate well with a glass rod and add 100 cc. of distilled water. Solution should occur at once but, in case any undissolved material is left, gentle warming will hasten solution and do no harm. Pour into a liter flask, washing out the beaker with 100 cc. distilled water. Add the 740 cc. of dilute hydrochloric acid remaining, with shaking, and dilute to 1 000 cc. with distilled water.

This will give a reagent of sufficient acidity to meet practically all conditions in the testing of water and sewage, using the comparator method. In the case of most waters 0.5 cc. of this reagent to 15 cc. of sample is sufficient. With sewage and trade wastes, however, the use of 1 cc. of reagent to 15 cc. of sample is advisable.

Attempts to substitute sulphuric for hydrochloric acid in the ortho-tolidin reagent led to much the same conclusion as reached by Ellms and Hauser,[13] that such a solution "is not as easily prepared as one of hydrochloric acid." The sulphate of ortho-tolidin is not particularly soluble, and solutions containing as low as 4.6 g.p.l. of sulphuric acid caused the salt to precipitate. This is what would be expected in view of the fact that the low solubility of the sulphate has been used as the basis of a quantitative method for sulphates by Raschig.[14]

With respect to the time of development and persistency of the ortho-tolidin color, it was found that, with water, maximum development usually took place within 1 to 3 minutes and the color as a rule persisted for 20–30 minutes. In the case of sewage and trade wastes, maximum color developed in from 1 to 15 minutes but usually in less than 5 minutes, after which fading of the color set in. It is advisable to make the reading at the time when the maximum color has developed. With water a five-minute period is recommended.

It should be remembered that temperature has some influence but, fortunately, this is quite small over the range normally encountered, namely, 20 to 30° C. Low temperatures materially retard the color development and it is always advisable to have the sample between 20 and 30° C. (68 to 86° F.).

Some workers[15] have reported that direct sunlight has an inhibiting effect on the color development. This may be true at low concentrations, but in the range covered by the comparator method no such effect was noted.

In controlling the chlorination of sewage the results secured by the iodine-thiosulphate method are generally higher than are found with ortho-tolidin. This has never been thoroughly explained, but preliminary work in our laboratory would indicate that certain chlorination and partial oxidation products of amines may liberate iodine and have very slow action on ortho-tolidin. If similar products were formed in the chlorination of sewage, the total iodine liberated would not be a measure of the residual chlorine alone. That such reactions do actually occur, however, remains to be demonstrated.

In conclusion it may be stated that

1. A modified ortho-tolidin method based on the use of a comparator and standard color tubes, similar to those used in the colorimetric determination of hydrogen ion concentrations, has been devised.

2. This comparator has been found to give reasonably accurate results over the range 0.1 to 10 p.p.m. of chlorine in the presence of turbidity, color, and such interfering substances as manganese, iron, and nitrites.

3. The pH required at the time of color formation, to give a satisfactory color in the ortho-tolidin test, has been determined and found to be not over 2.0.

4. The amount of hydrochloric acid which can be incorporated in the ortho-tolidin reagent with one gram of ortho-tolidin has been found to be not over 98 g.p.l. at 25±1° C.

5. The time of development and persistency of the "ortho-tolidin chlorine color" has been investigated as well as the effect of light and temperature.

6. A method is given for the preparation of an ortho-tolidin reagent that will produce the proper conditions in applying the ortho-tolidin test to waters, sewage, and trade wastes.

Acknowledgment: The author wishes to thank W. R. Kenny, of the LaMotte Chemical Products Company, for valuable assistance in the laboratory.

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Discussion.

L. H. Enslow.* I would like to make one correction, if I may. Ellms and Hauser in their original method covering the preparation of ortho-tolidin in hydrochloric acid solution did not stipulate hydrochloric acid (HCl) as 10 per cent. by weight. The original literature specifies a solution containing 10 per cent. by volume of concentrated hydrochloric acid solution.

It becomes an important matter to have a solution more acidic than that specified in the A. P. H. A. Standard Methods when determination of residual chlorine is to be made in connection with sewage chlorination. The increased acidity is essential to overcome buffering by the soluble and pseudo-soluble solid content of the sewage. One cubic centimeter of the standard ortho-tolidin solution added to 100 cc. of sewage will frequently produce no color, or just a trace, whereas the addition of more dilute acid (not ortho-tolidin solution) will reduce the pH of the sample and cause a decided yellow color to appear. There is no deficiency of ortho-tolidin, but merely a lack of hydrogen ion concentration, which accounts for the failure of the standard solution to indicate the true value of residual chlorine in sewages and other highly buffered or alkaline solutions. It has consequently been found advantageous to employ a modified ortho-tolidin solution of maximum acidity which can be secured without causing after-precipitation of the ortho-tolidin. Investigation by the LaMotte Company and others has indicated this strength to be 20 per cent. by volume of concentrated hydrochloric acid, i.e., in the neighborhood of 8.5 per cent. HCl by weight.

Further, in order to conserve this reagent, a volume of 15 or 20 cc. of sewage sample is sufficient for the test, and addition of not more than 0.5 cc. of the ortho-tolidin solution is required. The solution contains the same proportion of ortho-tolidin as does the standard solution, i.e., 0.1 per cent. by weight.

The comparator method of determining residual chlorine has as its chief advantage its adaptability in connection with highly turbid solutions such as sewages and industrial wastes. Also the presence of manganic salts, iron salts, nitrites or other interfering materials, is largely, if not entirely, compensated for when employing comparator methods for residual chlorine determination.

The permanent standards compounded from copper sulphate and potassium dichromate in accord with the "A. P. H. A. Standard Methods" to represent various free chlorine concentrations are not adapted for use in tubes other than the standard 50 cc. Nessler tube. Investigation by LaMotte Chemical Products Company has shown that the standards representing 0.1 and 0.2 p.p.m. of residual chlorine give the same results in Nessler tubes as in the smaller tubes viewed transversely. Above this range an error appears, and, therefore, it has been necessary to prepare

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for use in the small tubes a new set of permanent solutions that will give correct residual chlorine readings.

A remark should be made concerning the length of contact after addition of the acid ortho-tolidin solution before recording the color developed. In some instances the color develops very quickly, reaches a maximum, and thereafter fades. This is because of the increased chlorine absorption resulting from the reduced pH of the medium; thus the chlorinated ortho-tolidin is gradually robbed of its chlorine and the compound is again converted into the colorless ortho-tolidin. In other instances the reverse is the case and color development is very gradual, and fading is also gradual. This is more commonly true of settled or crude sewage, whereas the color development and subsequent fading may be rapid in the case of certain effluents, such as poor activated sludge effluent or deficient sprinkling filter effluent in both of which albuminous substances and free ammonia are high. The remedy in such instances is a reduction in the quantity of the acid ortho-tolidin so as to obtain a more lasting yellow color. Regardless of the circumstances the maximum color should be watched for and this taken as the most nearly correct residual "available" chlorine content. Usually the period of contact with sewages and other solutions at a temperature above 20° C. is not more than one or two minutes before maximum color development is secured.

An easily manipulated method of preparing ortho-tolidin solution is that of Theriault (U. S. P. H. S. Reprint No. 1145, and Public Health Reports, March 11, 1927). Theriault's method should be modified to the extent that 200 cc. concentrated hydrochloric acid per liter are employed instead of the stated 100 cc.

Edward E. Minor.* In water sterilization, the final measure of efficiency must always be a bacteriological test. We have found quite a difference in operating dry gas chlorination and the solution feed type. With the latter we can apply less chlorine and work with less residual chlorine than we could with the dry gas machine. We have found solution feed to be much more efficient, and I think the residual chlorine is of less importance here than it is with dry gas chlorination.

E. Sherman Chase.† I suppose it is true that the bacteriological analyses are the proof of the pudding. But there are occasions when you have to rely upon your excess chlorine tests, and that is when you are applying chlorine as an emergency measure to highly polluted supplies.

During the War the city of Watervliet, N. Y., had occasion to pump directly from the Hudson River into its mains to supplement the regular water supply. There was only one thing to do, and that was to put in an emergency chlorination plant. We could not wait for 24 hours to elapse to determine the bacteriological results of that chlorination. Absolute reliance had to be placed on getting an excess of chlorine. At that time

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we used the starch-iodide test in view of the fact that the ortho-tolidin test was not quite so well developed as it is today. In such an instance, the excess chlorine test affords a method for determining the efficiency of the chlorination, an extremely vital consideration.

STEPHEN DEM. GAGE.* I would like to add just a word to what Mr. Chase has said about the use of excess chlorine, especially in the case where you are dealing with colored waters. A good many of our New England waters are used without filtration and chlorine is relied upon as a factor of safety. These waters vary widely from time to time in their organic content, which may be represented by the color. I have in mind one unfiltered Rhode Island supply that is chlorinated as a factor of safety. The color of the water may increase overnight from 25 p.p.m. to 70, 80, or 90 p.p.m. In the early days of chlorine treatment we tried to work out a ratio between color value and the amount of chlorine that must be used to satisfy this organic matter and still provide an excess of disinfectant to kill the bacteria which might be present. We were unable to find any ratio of this kind which could safely be used. While these supplies were from unpolluted sources, there was always the feeling that there might be chance pollution, and until the ortho-tolidin test for excess chlorine was worked out we were never sure of the effectiveness of our disinfection process. Another side to this question is that with this type of waters you may sometimes have a rapid color drop, and the chlorine demand might be so reduced that you would have an excess sufficient to cause complaints from the consumers. The only safe way to handle the chlorination dosage on these colored waters is on the basis of the excess chlorine as shown by frequent tests.

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ONE YEAR'S OPERATION OF THE PROVIDENCE FILTRATION PLANT.

BY JULIUS W. BUGBEE* AND ELWOOD L. BEAN.†

[*Read September 16, 1927.*]

The new water supply of the city of Providence is familiar to the members of this Association, through the papers describing its various features which have been presented at the annual conventions, and through visits made while construction work was in progress.

Briefly outlined, the Scituate project consists of a catchment area of 92.8 sq. miles, 25 per cent. of which is owned by the city; an impounding reservoir covering 5.6 sq. miles, with a storage capacity of 37 billion gal.; a hydro-electric plant to utilize water sent to the mills downstream; purification works, an aqueduct built partly in tunnel and partly in cut-and-cover, steel and reinforced concrete pipe lines, and two covered distributing reservoirs.

The purification works, whose first year of operation is the subject of this paper, were thoroughly described in a paper read by Walter W. Kittredge before this Association on September 16, 1926, and published in the JOURNAL for December, 1926. These works consist of an influent aërator, a head-house for storage and application of coagulant, a rotary mixer, two coagulating basins of 31 million gal. and 94 million gal. capacity, respectively; ten rapid sand filters with a rated capacity of 48 m.g.d., an effluent aërator, and a chemical house for the storage and application of lime and chlorine.

The plant was put in operation on September 30, 1926, six filters having been completed at that time, and nineteen billion gal. having been stored in the reservoir. The surface elevation of the reservoir had reached 265, or 16 ft. above the surface of the sand in the filters. The south coagulating basin was still uncompleted, and the north basin, having a capacity of 31 million gal., was used alone until February 1, 1927. Filters 7, 8, 9 and 10 were completed and put in service between September 30, 1926, and January 1, 1927. Until all construction contracts were completed the plant was operated by the Water Supply Board, and the formal transfer to the Department of Public Works was made on July 3, 1927. The power plant is still being operated by the Water Supply Board, and electric current is sold to the Department of Public Works.

Preliminary studies of treatment methods were handicapped by the fact that no water had been stored in the reservoir, and the character of the water to be treated was therefore problematical, depending on the pro-

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portions received from the various tributaries, and the effect of storage in a new, unstripped reservoir. Numerous experiments were conducted, using samples of water from the ponds and streams in the drainage area, with various amounts and combinations of chemicals, with and without aëration, and a course of treatment was laid out, which has been successful in meeting the conditions actually encountered during the past year.

The intake at elevation 235 to 240 has been used during the entire year. The surface level has varied between 263 and 278, or 25 to 40 ft. above the intake, which is itself 40 ft. above the bottom level at that point. This intermediate level has appeared to be the most desirable, as the distance from the surface insures freedom from ice troubles in winter and avoids most of the microörganisms in summer; while, on the other hand, iron and color are lower than if the water were taken from the extreme depth.

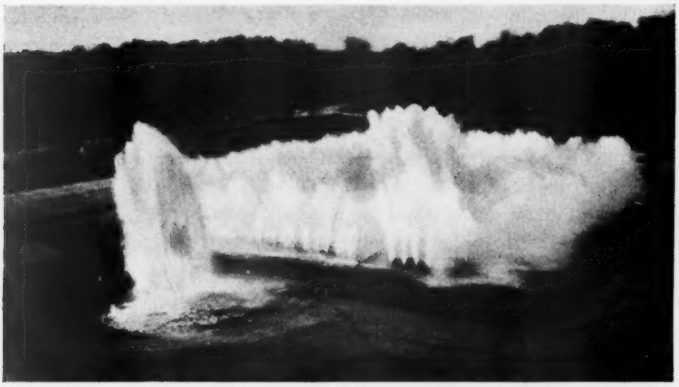

FIG. 1. — INFLUENT AËRATOR — PROVIDENCE FILTRATION PLANT.

Water for the mills has been discharged through the upper intake at elevation 252 to 260, according to the terms of the city's contract with the mill owners. This contract specifies that if the reservoir level is between 284 and 260, the upper intake shall be used, while if the surface level drops below 260, water shall be sent to the mills through the intermediate intake at 235 to 240.

Alum has been used as a coagulant throughout the year, the quantity varying between 0.7 and 0.5 grain per gal., except for a short period in November and December, when one grain per gal. was applied. As originally designed, the alum-solution pipes were so arranged that the coagulant could be applied either before or after aëration. When operation of the plant was begun, alum was added before aëration, but it was found that the distance between the alum-feed line and the lines leading to the several sets of aërator nozzles was too short to allow of thorough mixing, and that the greater part of the alum solution passed through the first set of aërator

nozzles. Changes now under way are intended to correct this condition by diffusing the alum solution through the entire cross-section of the main conduit, and until these changes are completed, alum is being applied after aëration.

Carbon-dioxide content of the raw water has varied between 2 and 9 p.p.m. Starting at 5 p.p.m. in October, it increased to 6 in November, then slowly decreased to 3.5 in December, again increasing during the colder weather to a maximum of 8.5 in late January, followed by a slow decrease to a minimum of 2 in early May, with another increase to 9 p.p.m. in early August. Removal of CO_2 has varied with the fluctuations in the raw-water content and with the temperature. With the raw-water temperature below 50° F. and the air temperature below 60°, in February, March and

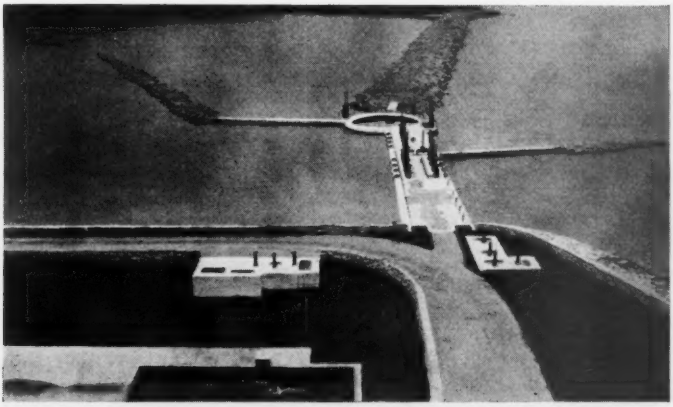

FIG. 2. — MIXING CHAMBER — PROVIDENCE FILTRATION PLANT.

April, aëration reduced the CO_2 from 8 p.p.m. to 5, from 6 p.p.m. to 4, and from 4 p.p.m. to 3; but when only 2 p.p.m. were present, in late April and early May, the reduction was 0.3 p.p.m. In May, June and July, with water temperatures between 50° and 60°, and air temperatures between 50° and 80°, greater removal of CO_2 was obtained, averages showing reductions from 8 p.p.m. to 4, 6 p.p.m. to 3.2, and 4 p.p.m. to 2.5.

The changes in pH due to aëration have corresponded closely with the changes in CO_2. Raw water of pH 6.1 has been raised to 6.4; 6.5 to 6.8; 6.7 to 6.9 and 6.9 to 7.0.

Efficiency of aëration is affected somewhat by the different rates of operation. With the reservoir at 278.50, the maximum height reached during the year, the height of spray can be made to vary between 7 and 15 ft., depending on the number of sets of nozzles in use. With the reservoir at this height, it is possible, by using a single set of nozzles, or various combinations of two, three or four sets, to obtain fifteen different rates of discharge, varying from 20 to 85 m.g.d.

Experiments have established 5.8 as the optimum pH for coagulation of this water; good floc formation and color removal take place when the pH is as low as 5.4; but alum is present in the filtered water when the pH of the treated water is below 5.7. Aëration of experimental samples following alum treatment, whereby the pH is raised above 6.1, has proved to be detrimental to floc formation. Both experimental and actual work have shown that with alum alone for a coagulant, proper floc formation will not take place above pH 6.2. In operation, the pH of the treated water has been maintained between 5.7 and 6.2.

In a series of experiments performed in January, with water of pH 6.5, color 30 p.p.m., and alkalinity 5 p.p.m., an excellent floc was formed with 0.7 grain per gal. of alum, while the addition of 0.1 grain of CaO in the form

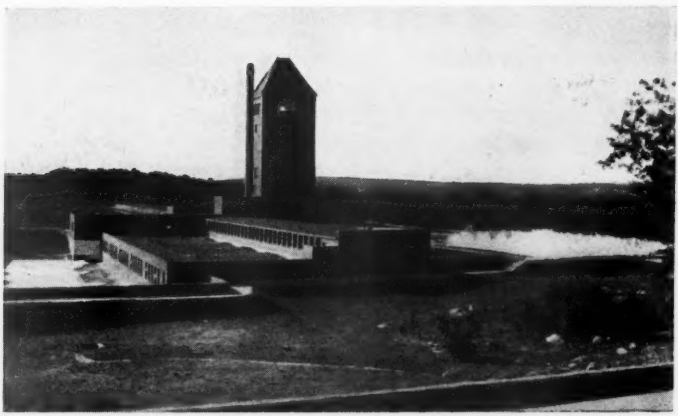

FIG. 3. — GENERAL VIEW — PROVIDENCE FILTRATION PLANT.

of hydrate increased the amount of alum required to 0.9 grain; with 0.16 grain of CaO, one grain per gal. of alum was necessary.

In March some experiments were made with sodium aluminate. The water used had a pH of 6.5, alkalinity 5 p.p.m., and color 37 p.p.m., and required 0.6 grain per gal. of alum for proper floc formation and color removal. Used in conjunction with sodium aluminate, 0.4 grain of alum was required with either 0.1, 0.2, or 0.3 grain of aluminate and 0.2 grain of alum with 0.5 grain of aluminate. The only apparent advantage of this treatment was a reduction of 1–2½ p.p.m. in the CO_2-content of the filtered water.

Alum used during the year has been purchased under a specification that requires that all dust and fine particles that will pass a screen having 10 meshes per linear inch shall be screened out, and that no particles shall be so large that they will not pass a three-quarter-inch screen. This grade of alum has been found to give better results in the dry-feeding machines

than the finer grade usually employed, all of which passes a 4-mesh screen, and 95 per cent. of which passes a 10-mesh screen. The entire freedom from dust is also a desirable feature, both in cleanliness of the building and in comfort of the operators. Deliveries have been made in 175-lb. bags, which are opened and dumped into the bucket conveyor which elevates the alum to the storage bins on the fifth floor.

Mixing of the alum solution and the aërated raw water is accomplished in a circular tank 35 ft. in diameter and 30 ft. deep. The treated water enters tangentially at the bottom and discharges at the top into the north coagulating basin. Samples taken from the outlet end of this mixer and compared with samples of water subjected to violent shaking by hand indicate that thorough mixing is accomplished in this manner.

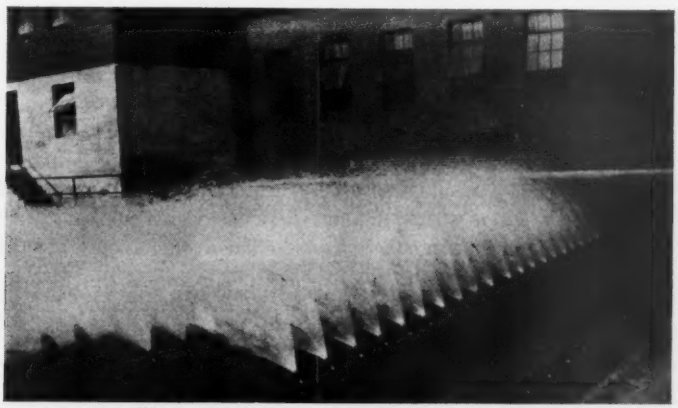

FIG. 4. — EFFLUENT AËRATOR — PROVIDENCE FILTRATION PLANT.

During the 4 months in which the small coagulation basin only was in service, the length of filter runs varied between 4 and 25 hours, with an average of only 13 hours. Since the second basin was put in service no run has been less than 11 hours, with a maximum run of 68 hours, the average for a six-month period being 29 hours. Just before putting the second basin into service the average filter run was 10 hours. Five days later an average of 46 hours was reached; this was maintained for the remainder of the month. No change of pH or temperature of water on the filters had taken place.

In February, with the filter temperature averaging 36° F., slightly longer runs resulted from a 16-in. wash for three minutes than from washes at other rates. With the temperature at 42° to 50°, in April, the longest runs followed washes of three minutes at 19-in. rates, giving a sand expansion of 35 to 40 per cent. In May, average runs of thirty hours or more followed washes with 30 to 35 per cent. expansion, while less than a 25-hour average was obtained with over 40 per cent. expansion. With a filter

temperature of 60° to 65° in June, it was found that while washes of 25 to 27 in. (sand expansion 35 to 40 per cent.) resulted in slightly lower initial loss of head than washes of 20 in. (sand expansion 20 to 25 per cent.), yet the length of runs was not increased, the loss of head increasing more rapidly during the first few hours of the run. A tendency to form mud balls while washing at these higher velocities was also noted. In July the average run of filters washed with 20 per cent. expansion was 10 per cent. more than those washed with 30 per cent. expansion. These results seem to indicate that the percentage sand expansion necessary to secure maximum length of filter runs is not constant, but varies between 20 and 40 per cent.

A length of wash of less than three minutes (calculated as the time between opening and closing the controls) has at all times proved to be insufficient, while washes of more than three minutes have shown little or no advantage. Two minutes from the time of opening the hydraulic controls for the wash gates are required before maximum expansion of the sand is reached. A three-minute wash, calculated as stated, allows two minutes of maximum expansion of the sand, with a total time of flow of $4\frac{1}{4}$ minutes.

When expansion reaches 40 per cent. some sand is lost, while at 50 per cent. expansion it would waste very rapidly. The original depth of sand placed in the filters was 30 in., and there has been a constant decrease in depth, with an increase in effective size. The average depth of sand on December 1, 1926, with seven beds in operation, was 28.8 in., with an effective size of 0.37 mm. On August 1, 1927, the average depth had decreased to 27.3 in., while the effective size had increased to 0.40 mm. The losses of sand were so distributed among the various sizes that the uniformity coefficient remained practically constant at 1.45.

Each filter has a sand area of 1 738 sq. ft., which is divided into two equal parts by a water conduit (influent and drain) midway of the filter and extending above the tops of the wash troughs. Excepting the influent and drain gates, each half has its own and entirely independent controls for all operations. The filters were designed for a capacity of 4.8 m.g.d., or 2.4 m.g.d. for each half, but are being operated at a rate of 2.2 m.g.d. per half bed, equivalent to 110 m.g.d. per acre.

The rate of operation of each half filter is regulated by a controller equipped with a diaphragm, which gradually opens a mushroom nozzle as the loss of head increases, allowing a portion of the filtered water to be discharged without passing through the effluent-aërator nozzles. In this way the rate is kept nearly constant until the bed refuses to pass the required amount. The difference in elevation between the flow line of the filters and the effluent-aërator nozzles is 10 ft., and the filters can be operated at the established rate until the loss of head reaches $7\frac{1}{2}$ ft. The initial loss of head on beds making the longest runs is between 1.4 and 1.8 ft.

A filter-temperature minimum of 34° F. was reached in early January, rising to a maximum of 69° in late July.

Color of the raw water has varied from 20 to 40 p.p.m., with an average (10 months) of 30, while the color of the final effluent has averaged 5 p.p.m., with a maximum of 10.

Carbonic acid in filter effluent has varied from 3.5 to 9.9 p.p.m., the maximum being the December average, when the alum treatment was one grain per gal., with one coagulating basin in service. When the second basin was put in commission the CO_2 dropped to 7 p.p.m., with a constant decrease to 2.5 p.p.m. in August. The corresponding figures for pH were 5.9 in December, increasing to 6.5 in August. Removal of CO_2 by effluent aëration has varied with air and water temperatures, and with the CO_2-content of the filter effluent. In February an effluent containing 6.7 p.p.m. of CO_2 lost 2.1 p.p.m. by aëration, in April 3.7 p.p.m. were reduced by only 0.6 p.p.m., while in July 3 p.p.m. were reduced to 2. Monthly averages of pH have shown a fairly uniform increase of 0.2, due to aëration.

An attempt was made to increase the efficiency of one effluent aërator by plugging one-half of the nozzles. The water passing through the remaining nozzles showed a CO_2-content of 4 p.p.m., compared with 4.5 to 5.0 for the other aërators using the full set of nozzles. An increased amount of water, however, was forced through the mushroom nozzles in order to maintain the proper rate of filtration, and the much lower removal of CO_2 in the flow through the mushrooms counterbalanced the increased removal in the aërator nozzles.

Before the new plant was connected with the city mains, the aqueduct and the steel pipe line were completely filled with water which had been given a chlorine treatment of 3 p.p.m. This water was allowed to remain in the conduits for several days and was then wasted through blow-offs on the line, until tests showed a sufficient reduction in excess chlorine. Chlorination of the filtered water was carried on until December 5, and then was discontinued until the middle of July. Since that time chlorine has been applied in amounts varying from 0.15 to 0.25 p.p.m., the amount being so regulated as to maintain a residual chlorine of 0.1 p.p.m.

The bacterial content of the raw water has been very low throughout the year. Since January 1, the average 37° C. count has been 21, with a maximum of 200, and the average 20° count has been 100, with a maximum of 300. Considerable increase, particularly in the 20° count, has taken place in the coagulating basins during the warm weather, the July averages being as follows: Raw water 36 at 37°, 150 at 20°; settled water 740 at 37°, 2 450 at 20°. Samples from various points in the coagulating basins showed that the maximum was reached after about two days' detention, with a decrease before passing on to the filters.

B. *coli* are practically absent from the water. Since January 1, only four raw-water samples and one city-tap sample have shown positive presumptive tests in 10 cc., out of a total of 200 samples from each source. The final effluent from the plant has been uniformly negative throughout the year.

Hydrated lime has been used continuously to supplement the work of the effluent aërator in the removal of free carbonic acid. The pH of the aërated effluent has varied between 6.0 in December and 6.7 in July, with corresponding variations of CO_2 between 8.0 and 2.5 p.p.m. By adding amounts of hydrated lime varying from 10 to 40 lbs. per million gal., the pH of the final effluent has been held very uniformly at 7.4, with a CO_2-content of 1.5 p.p.m. Examination of water from lead service-pipes has been continued through the year, and no samples examined have shown lead in excess of 0.05 p.p.m.

During the first four months of operation, the north coagulating basin was used alone. The detention period in this basin, which has a capacity of 31 million gal., was found to be too short for completion of the reaction. The 94 million gal. south basin was completed and put into commission on February 3, 1927. The storage capacity of the two basins between elevations 254 and 255.50 is 17 million gal., and, because of this fact, it has been possible to concentrate the influent aëration and alum treatment into the eight hours between 8 A.M. and 4 P.M. The basins are filled to their maximum capacity at 4 o'clock, and the draft on the filters during the night is cared for by the 17 million gal. above elevation 254. Also all filter washing is done during this same eight-hour period from 8 A.M. to 4 P.M. In this manner almost all of the electric power required is generated by the power station at the gate-house, which operates only during the hours in which mill water is being discharged, between 5.30 A.M. and 3.30 P.M. Another economy, made possible by this arrangement of treatment and filter washing, is the reduction of the operating force to one man between the hours of 4 P.M. and 8 A.M.

The force, as constituted at present, consists of a chemist, a master mechanic, three men on the day shift, from 8 A.M. to 4 P.M., one man from 4 P.M. to 12 P.M., to one man from 12 P.M. to 8 A.M. A relief operator, who works four days per week from 8 A.M. to 4 P.M. and two days from 4 P.M. to 12 P.M., provides one day off in seven for all employees, and also permits alternating the two night men on the second and third shifts. These six men are all rated as utility men, and are used in all parts of the work, including chemical treatment, filter washing, pump operation, storage of chemicals, janitor service, minor repairs and care of grounds.

As there is no clear-water storage at the plant, it has been necessary to govern the rate of filter operation by observations of the height of Hope Reservoir, on the east side of the city. These readings are telephoned to the plant every two hours by the operators at Hope Pumping Station, and it has been possible by this method to maintain satisfactory pressures throughout the city. It is expected that on the completion of Neutaconkanut Reservoir, which will be connected directly with the aqueduct by a 60-in. pipe line, it will be possible to operate the filters on a more uniform schedule, without being obliged to follow so closely the fluctuations in draft.

TABLE 1.

SUMMARY OF OPERATION, OCTOBER 1, 1926, TO OCTOBER 1, 1927.

	Amount filtered.		Alum.			Lime.			Chlorine.		
	Million gal.	m.g.d.	Lb.	Lb. per day.	Grains per gal.	Lb.	Lb. per day.	Grains per gal.	Lb.	Lb. per day.	p.p.m.
October	716.48	23.112	76 080	2 454	.74	14 815	478	.15	780	25.0	.14
November	707.17	23.572	78 787	2 626	.78	18 677	623	.19	304	10.1	.05
December	747.17	24.102	108 665	3 505	1.01	19 900	642	.19	40	8.0	(5 days)
January	763.76	24.636	81 600	2 632	.75	18 600	600	.18	..	..	...
February	649.16	23.184	63 105	2 254	.68	18 350	655	.20	..	..	...
March	726.79	23.445	62 035	2 001	.60	16 100	519	.15	..	..	...
April	689.59	22.986	57 310	1 910	.61	12 000	400	.12	..	..	...
May	721.67	23.279	62 665	2 021	.62	11 650	376	.11	..	..	...
June	749.32	24.977	58 130	1 938	.54	10 550	352	.10	..	..	...
July	746.04	24.066	54 640	1 762	.51	8 900	287	.08	591	32.8	(18 days)
August	716.37	23.109	50 275	1 622	.49	10 500	339	.10	1 112	35.8	.19
September	727.86	24.262	64 300	2 143	.63	10 300	343	.10	1 268	42.3	.21
Total	8 661.38		817 592			170 342			4 095		
Average		23.730		2 240	.66		467	.14		..	....

	Filters washed.		Average run, hrs.	Wash Water.			Influent Treatment. Hrs. per day.
	Total.	Per day.		Million gal.	m.g.d.	Per cent.	
October	403	13.0	9.03	41.78	1.348	5.8	21.5
November	233	7.8	14.34	29.28	.976	4.1	19.9
December	233	7.2	16.11	26.74	.862	3.5	19.3
January	339	10.9	11.15	36.73	1.184	4.8	17.9
February	105	3.7	31.09	15.06	.538	2.3	21.2
March	112	3.6	37.08	16.24	.524	2.2	15.4
April	134	4.5	29.59	11.84	.394	1.7	8.7
May	145	4.7	28.10	14.67	.473	2.0	10.0
June	275	9.2	16.26	25.77	.859	3.4	11.9
July	213	6.9	20.42	18.54	.598	2.5	9.8
August	183	6.9	22.35	17.57	.567	2.4	9.2
September	238	7.9	17.96	22.61	.754	3.1	9.7
Total	2 613			276.83			
Average		7.1	18.05		.759	3.2	14.2

TABLE 2.

AVERAGE PHYSICAL AND CHEMICAL QUALITY OF WATER, OCTOBER 1, 1926, TO OCTOBER 1, 1927.

Results are p.p.m. unless otherwise stated.

	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Average.
Hardness:													
Raw	9	9	9	11	10	9	9	8	8	8	8	8	9
Filtered	11	11	13	14	13	13	12	11	11	9	10	9	11
Final	16	15	17	17	17	17	15	13	14	13	14	13	15
Alkalinity:													
Raw	7	7	6	5	5	5	5	5	4	4.3	5.3	6.9	5.5
Filtered	4	3	1	1	1	1	1	1	1	1.5	2.5	3.3	1.6
Final	7	6	4	4	5	5	4	3	4	3.4	4.2	5.2	4.6
Hydrogen Ion:*													
Raw	6.5	6.5	6.8	6.5	6.3	6.4	6.7	6.8	6.5	6.2	6.1	6.2	6.5
Aërated	..	6.8	..	6.7	6.6	6.7	6.8	6.9	6.8	6.6	6.6	6.6	..
Treated	..	5.8	..	6.0	5.8	6.0	6.1	6.0	6.1	6.1	6.1	6.1	..
Settled	6.0	6.0	5.8	6.0	6.0	6.2	6.4	6.3	6.4	6.4	6.3	6.3	6.2
Filtered	6.1	6.0	5.9	6.0	6.0	6.2	6.4	6.3	6.4	6.5	6.4	6.3	6.2
Aërated eff.	6.2	6.2	6.0	6.2	6.2	6.4	6.6	6.5	6.6	6.7	6.7	6.6	6.4
Final	7.2	7.6	7.1	7.1	7.3	7.6	7.2	7.2	7.6	7.4	7.2	7.1	7.3
Free Carbonic Acid:													
Raw	5.2	5.2	3.8	6.9	6.8	5.3	2.7	2.2	3.6	6.8	9.2	7.9	5.5
Aërated	..	3.7	..	5.3	4.2	3.5	2.2	1.9	2.3	3.2	4.4	4.4	..
Treated	..	13.0	..	11.8	10.7	8.5	6.9	6.7	6.2	6.4	7.0	7.8	..
Settled	7.3	9.4	10.5	10.1	8.1	5.5	3.9	3.7	3.5	3.6	4.4	4.8	6.2
Filtered	6.4	7.6	9.9	9.5	7.8	5.3	3.7	3.7	3.4	3.5	4.1	4.4	5.8
Aërated eff.	4.8	5.5	8.0	7.2	5.3	3.9	3.1	3.0	2.6	2.5	2.3	2.6	4.2
Final	1.7	1.3	2.1	3.2	1.8	0.8	1.1	1.3	0.8	1.2	1.1	1.5	1.4
Color:													
Raw	38	25	23	27	33	39	34	25	28	29	43	43	32
Filtered	11	5	4	5	7	7	5	4	4	5	9	14	7
Tap	18	11	10	13	4	6	6	5	4	6	9	17	9
Turbidity:													
Raw	..	..	.7	.6	.8	1.4	1.5	1.4	1.7	1.9	2.0	2.0	1.4
Settled	..	..	.4	.7	.6	.4	.5	.4	.4	.4	.5	.8	.5
Filtered	..	..	0	0	0	0	0	0	0	0	.1	.2	0
Iron:													
Raw	..	..	..	.4	.5	.45	.3	.3	.4	.45	.7	.7	.47
Settled	..	..	..	.3	.2	.3	.2	.2	.3	.25	.3	.5	.28
Filtered	..	..	..	..	..	..	.1	.2	.3	.25	.2	.4	.24
Tap	.8	.5	.6	.4	.5	.3	.3	.2	.2	.25	.3	.4	.40

*Concentration as pH.

TABLE 3.

AVERAGE BACTERIOLOGICAL QUALITY OF WATER, OCTOBER 1, 1926, TO OCTOBER 1, 1927.

	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Average.
*B. Coli Presumptive**													
Raw	0/4	..	..	2/22	0/18	0/23	0/26	2/25	0/25	0/25	3/27	3/25	10/220
Settled	2/23	..	..	1/25	1/21	0/23	1/26	0/25	0/25	1/25	5/27	7/25	18/245
Filtered	..	..	0/17	0/25	0/20	0/23	0/26	0/25	1/25	1/25	5/27	2/25	9/238
Chlorinated	3/23	1/18	0/3	..	..	..	..	..	..	0/14	2/27	2/25	..
Tap	13/23	7/24	0/21	0/25	0/21	0/23	1/26	0/25	0/25	0/25	1/27	1/25	23/290
20-Degree Count†													
Raw	..	..	..	68	161	90	92	67	79	153	93	120	91
Settled	..	..	..	129	44	295	829	2 027	3 459	2 452	1 053	632	1 213
Filtered	..	..	..	108	159	268	348	1 382	1 720	2 269	763	318	815
Chlorinated	..	..	..	..	..	..	..	..	..	119	50	52	..
Tap	..	..	..	71	81	164	168	146	108	81	73	50	105
37-Degree Count†													
Raw	35	16	25	14	15	39	10	12	24	36	34	16	23
Settled	1 624	42	6	5	3	7	19	91	226	741	690	235	307
Filtered	..	..	3	5	4	8	29	84	393	1 897	638	124	318
Chlorinated	1 091	97	..	..	..	..	..	..	..	152	58	20	..
Tap	320	82	6	4	2	4	6	10	14	24	36	12	43

*10 cc. Portions positive.
†Number of Colonies.

The estimated quantities of materials for the year beginning October 1, 1927, are as follows:

Sulphate of alumina	320 tons.
Hydrated lime	100 tons.
Chlorine	8 000 lbs.
Coal	400 tons.

The estimated expense of operation for the same period is $38 000. This includes labor, chemicals, electric power, fuel, miscellaneous supplies, repairs, and care of grounds.

A summary of operation data will be found in Tables 1, 2 and 3.

Discussion.

Allen Hazen.* It is a great pleasure to hear about the operation of the Providence plant. The plant was laid out with the deliberate intention of making things automatic and economical to operate as far as this could be done with reliable equipment and without taking unnecessary chances. It is gratifying to hear from Mr. Bugbee that this program has worked out successfully.

It is really quite an achievement to have a plant of this size that will operate for 16 hours out of the 24 with only one man at a time on duty. The automatic devices in this case are so perfect that the plant would undoubtedly go through these 16 hours without even the one man, but one man is perhaps a minimum operating force for a plant of this kind and should be kept on duty to act in any possible emergency.

Some years ago we used to estimate as a rough rule that one man would be needed for every million gal. of daily average output. That was a rough rule but one not far out for plants of a certain date. Now at Providence the operating force only amounts to two hours' work per million gal. of daily output, or about one-fourth of that indicated by the old rule.

F. N. Connet.† The general scheme of rate control was devised entirely by Hazen and Whipple, although I coöperated with them and modified our standard Venturi controllers to fit these unusual conditions. The current issue of *Engineering News-Record* describes the general arrangement. A standard Venturi meter tube is used in each effluent pipe, and beyond this is a T-branch and a gate valve so that the flow can be diverted either to the large adjustable aërator nozzle or to an hydraulically operated butterfly valve and thence to the clear well. This butterfly valve will be used only during severe winter weather when the out-of-door aërator nozzle might freeze up. Each indicating instrument on the operating table is connected to two controllers, one for each half of the filter bed, and has five dials. Two dials show the rate of flow, two show the loss of head, and the fifth dial shows the elevation of water on the bed.

E. Sherman Chase.‡ I would like to ask if the cost of operation per million gal. has been determined.

Mr. Bugbee. I have nothing definite regarding the cost of operation during the past year, because changes were being made during the first few months; but on the basis of our estimate for the coming year, it is going to cost $4.34 per million gal. This cost per million gal. is based on an estimated rate of 24 m.g.d., while the plant was designed for 48 m.g.d. If the rate were increased to 48 m.g.d. the additional labor, chemicals and power required would bring the cost up from $38 000, the estimate for the coming year, to $60 650, which would give a cost of $3.46 per million gal. At present the labor required for operation is 2.3 man-hours per million gal.,

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†Builders Iron Foundry, Providence, R. I.
‡Of Metcalf and Eddy, Consulting Engineers, Boston, Mass.

while at the 48-m.g.d. rate this would be reduced to 1.43 man-hours per million gal.

L. H. ENSLOW.* I would like to call to your attention a matter that is important when computing the efficiency of aërators. It is usually customary to take the laboratory figures reported as "CO_2 removed" as the index of aërator efficiency. This method applied to many waters — and Providence raw water is one of them — is subject to error in that it will indicate an efficiency of aëration lower than is actually obtained. The source of the error is found in the apparent CO_2-content as indicated by titration with a standard alkali, but all of which is not CO_2 and cannot be removed completely by the most efficient aëration. The trouble is due to ferrous iron compounds, weak organic acids such as humic and tannic acids, and other organic matters that absorb alkalies. In recording CO_2 in pre-aërated and aërated waters containing organic matter it is necessary to determine the "blank," i.e., that portion of apparent CO_2 which cannot be aërated out in the laboratory. This blank if appreciable should be deducted from the CO_2-content of the pre-aërated and aërated water before computing aërator efficiency. I have jotted down some figures indicating the effect of such a blank when calculating aërator efficiencies.

We will assume that the blank represents 2 p.p.m. of so-called CO_2. Assume the raw water shows by titration an apparent CO_2-content of 10 parts and the aërated 3 parts. The usual procedure would show an efficiency of aëration of but 70 per cent., whereas, correcting for the blank, an efficiency of 87.5 per cent. is indicated and is the true figure.

Likewise in the case of an apparent CO_2-content of 7 p.p.m. in the raw water reduced to 3 parts in the aërated apparently the efficiency of removal is but 57 per cent., whereas, corrected for the blank it is actually 80 per cent. In cases where the CO_2-content is above 20 p.p.m. and the blank is but 2 parts, the error becomes 10 per cent. or less in the efficiency calculations. In all cases, however, this probability of error in calculating aërator efficiency deserves more consideration than it has been given in the past when comparing efficiency of aërators on the CO_2-reduction basis.

It is believed that Providence aërators are in truth more efficient than the laboratory reports of CO_2 reduction would indicate; more particularly is this the case during periods of the year when the color and organic content of the raw water are highest.

A MEMBER. I think the Providence plant is one of the most interesting plants I have ever visited, but I have often wondered what the carrying charges were on that plant and whether or not the carrying charges were carried in the water rates. If this information is available I would like to know.

PRESIDENT WINSOR. I think that, roughly, the Providence Filter Plant cost about $1\frac{3}{4}$ million dollars with all apparatus. The cost of the entire project will, I think, be about $20\frac{1}{2}$ million dollars. This figure in-

*Research Engineer, The Chlorine Institute, Inc., New York City.

cludes the cost of a 7-mile aqueduct with a 3½-mile tunnel, two covered distribution reservoirs with a combined capacity of 50 million gal., and seven miles of 60-in. and 48-in. lock-joint concrete pipe, carrying pressures up to 100 lb. per sq. in. The entire cost is carried in the water rates. The revenue is expected and, I think, is proving to be sufficient to carry all interest and sinking-fund charges as well as the cost of maintenance of the works.

FIGHTING FIRES BEFOREHAND.*

BY C. W. MOWRY.†

[*Read September 15, 1927.*]

The topic assigned to me was fire protection engineering, but instead of trying to cover this large subject even briefly, I have selected a single aspect of it which I have called "Fighting Fires Beforehand."

During the Russian-Japanese War, an American newspaper correspondent arrived at the Japanese Army Headquarters at the height of one of the worst battles in the Manchurian campaign. The correspondent expected to find material for a good story in the excitement and anxiety which he supposed always prevailed at an army headquarters during a battle; but imagine his surprise to find everything calm and peaceful, with General Kuroki, Commander-in-Chief of the Japanese Army, quietly fishing on the bank of a nearby stream!

As soon as the correspondent had presented his credentials and had been properly identified, he asked for an interview with the general; and at the close of the interview he said to the Commander-in-Chief as politely as possible, "You don't seem to be very much concerned about the outcome of this battle." "No," replied the wily little Jap, upon whose shoulders rested the entire responsibility, "No, I fought this battle two years ago back in Tokio."

I tell this story, which appeared in *Harper's Magazine*, because just as some battles can be fought beforehand by careful planning, by anticipating emergencies, and by preparing for them, so can some fires be fought beforehand by a study of the hazards involved, by developing suitable safeguards, and providing adequate protection; and just as actual warfare with its hand grenades, machine guns and heavy artillery is more spectacular and more easily understood than planning a campaign, so is actual fire-fighting with hand equipment, hose streams and water towers more spectacular and more easily understood than fire prevention and the science of fire protection.

One way in which the fire-protection engineer fights fires beforehand is by preventing fires. Some of you may ask how we know that fires are actually prevented. You may say that the fires might never have happened anyway and that we only think they are prevented. I could give you many illustrations of practical fire prevention. I could tell you, for example, of the experience of the Hood Rubber Company, Watertown, where more than one hundred fires occurred in the rubber spreader room within three years. This was traced to static electricity, and when a small

*This paper was illustrated by thirty-six lantern slides, five of which have been selected for the cuts in the Proceedings.

†Assistant Manager Inspection Department, Factory Mutual Fire Insurance Companies.

jet of steam was allowed to escape in the room in order to maintain the necessary relative humidity, the fires ceased; not a single one has occurred for two years.

I could tell you how the superintendent of a New Bedford cotton mill was sure that he had an enemy who was setting mysterious fires in the piles of cotton in his picker room, and how the cause was traced to the fact that the grease used on some of the machinery had been adulterated with horse fat to cheapen the product. The presence of this animal oil had resulted in spontaneous ignition. As soon as a change to a safe grease was made, the fires ceased; other mills using the dangerous product were notified, and thus many other fires were undoubtedly prevented.

I could tell you of a public utility company which had been troubled for twenty years with fires in their coal pile, resulting in a loss of 10–15 per cent. of the value of the coal, and how after adopting the packing and rolling process of storing the coal, which excludes the air and prevents spontaneous combustion, no fires occurred for three years, even though 200 000 tons were stored in a pile 30 ft. high.

I could go on and give you many other examples, but I have told enough, I think, to indicate that the fire-protection engineer really does prevent fires.

A method of fighting fires beforehand that will be more interesting to you as water-works engineers is that of providing means of putting out, as quickly as possible, those fires that cannot be prevented. Shakespeare had the idea even in his day, for he puts into the mouth of one of his characters these words, — "A little fire is quickly trodden out, which, being suffered, rivers cannot quench." Fire-protection engineers do not use such poetic language, but we do know that a pail of water at the start of a fire is of more value than the whole fire department later on.

New York City has the largest, best-trained, and best equipped fire department in the world, involving an expenditure of $6 000 000 annually; and yet, during the year 1926, 417 fires in New York City extended beyond the building in which they originated. Just think of it! An average of more than one fire per day throughout the year was not confined to the building in which it started. This is no fault or criticism of the New York Fire Department, but is merely an evidence of the importance of the first few minutes in fighting a fire.

Imagine, for example, a building or a manufacturing plant guarded by an army of watchmen stationed ten feet apart in each direction in every room on every story, and suppose that each one of these watchmen had a $\frac{1}{2}$-in. hose nozzle in his hand ready to turn on water the moment fire appeared. Suppose, still further, that these watchmen were on duty 24 hours a day, 365 days in the year, without a vacation, and that in case of fire they stuck to their posts with the hose streams. You would consider that building well protected, and yet that is exactly the form of protection provided by an automatic sprinkler system.

Here is the record of 36 000 fires controlled by automatic sprinklers. This was compiled by the National Fire Protection Association, of which Mr. Wentworth is the capable secretary. Fifty-one per cent. of these 36 000 fires were extinguished by two sprinklers or less; 81 per cent. by eight sprinklers or less. Each sprinkler having a ½-in. outlet discharges approximately 30 g.p.m. Eight times thirty is 240 g.p.m., or the equivalent of less than a single fire stream. This gives you an idea of the efficient use of water in 81 per cent. of the fires controlled by sprinklers. Ninety per cent. are controlled by 15 heads or less, and 95 per cent. by 35 heads or less.

In order to attain this remarkable record, however, automatic sprinklers must have a reliable water supply available at all times. This is the reason why so much attention is given to keeping sprinkler valves open. The usual practice in a sprinklered plant is to have the sprinkler valves inspected weekly to see that they are open. In addition to that, the insurance engineers visit the plant four times a year and check this valve inspection work, sealing the valves in the open position. And yet, in spite of this care, our inspectors last year in their visits to about 6 000 manufacturing plants throughout the United States and Canada discovered 500 sprinkler valves improperly closed. A few of these were valves on the city connections which had been closed by the water companies and forgotten, but the vast majority were under the direct control of the owners.

But closed valves are not by any means the only obstructions that prevent a full flow of water to automatic sprinkler systems. An inspector of the Underwriters Bureau of New England tells an interesting story about a new sprinkler system in Salem. While examining this system he noticed that the gage pressure on the sprinkler riser dropped nearly to zero when the drain valve was opened, but rose slowly to normal again when the drain was closed. A thorough inspection of the valves and supply line indicated a clear waterway until the Smith connection to the 20-in. street main was reached. Then it was discovered that the 1-in. drill used first in making the connection had penetrated the wall of the pipe all right, but that the cutting out of the disc had not been completed. Consequently, the only supply to the 6-in. sprinkler riser was the 1-in. drill-hole.

In another instance a lead disc 6 in. in diameter, one inch thick, and weighing over 11 lbs. completely obstructed the supply to nearly 500 sprinklers. Its discovery is another example of the value of making drain tests of new sprinkler equipment. Our inspector was examining the system for approval and obtained no water from the sprinkler drain. Here again all valves were found open, but upon removing the elbow at the base of the riser, the disc of lead, shown in Fig. 1., was found in the waterway of the controlling valve and was holding back 76 lbs. pressure. Evidently the gate valve and the attached nipple were assembled before being lowered into the trench. Apparently the valve was stood on its end while the lead joint was being poured, and a leak evidently existed in the yarn caulking,

permitting lead to flow on to the surface of the valve gate. The man pouring the joint should have noticed the excessive amount of lead being used, but apparently he did not.

When a 750-gal. pump was being tested by our engineer this summer a 20-in. vacuum was indicated in the suction line from the city main. A meter had been placed on this suction line, and the condition of its screen was therefore investigated. It was found that nine-tenths of the $\frac{3}{16}$-in. holes were obstructed by snail shells. The total area of the holes, even when clear, was less than that of the 8-in. suction line. Our experience has indicated that to insure an adequate quantity of water for a pump, a screen on the suction from a pond, river, or other body of water likely to contain

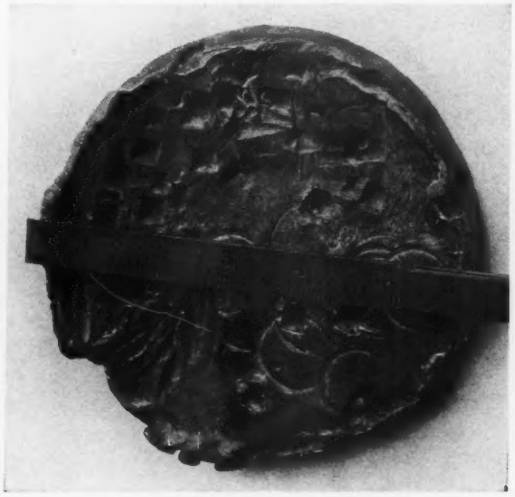

FIG. 1. — WHAT THE DRAIN TEST DISCLOSED.
This lead disc almost totally obstructed the flow of water to nearly five hundred sprinkler heads. The indentations in its surface were made while trying to remove it from the pipe.

much foreign material should have an effective area of ten times that of the pipe, but when the supply is from the street main, as in this case, about five times the area of the suction pipe is sufficient.

Foreign material is frequently found in the impellers of centrifugal pumps. Small stones and pieces of wood will clog the narrow outlets of the impellers without appreciably affecting the smoothness of operation. This cannot be detected by merely running the pump, but only by observing the pressure and measuring the discharge. In one recent case, a delivery of 1 200 g.p.m. at 35-lb. pressure was obtained at first from a 1 500-gal. pump, until the clogged impellers were cleaned, when the full rated capacity at 100-lb. pressure was delivered.

A piece of brick, which evidently got into the underground main while the piping was being laid, was washed up into a sprinkler system recently, and lodged in a 3½-in. x 3-in. x 2-in. tee, supplying thirty-six sprinklers. A fire started in the area protected by these sprinklers, and spread quickly over light combustible material, turning out great volumes of heat. The fire then spread into an adjoining building, flashing over deposits of wood dust on a joisted roof ahead of the operation of the sprinklers and opening so many heads as to overtax the water supply. The sprinkler control valves were then closed and effective pressure restored on the hydrants, hose streams from which were not able to control the fire. The building was destroyed with a loss of about $200 000.

FIG 2. — THREE-STORY WOODEN SHOE FACTORY.
Top story burned off after tank water was exhausted. City pressure was sufficient to save lower stories without assistance from fire department.

The effect of insufficient water pressure for sprinklers was strikingly shown at a factory which caught fire during the Salem conflagration. The city pressure was sufficient to supply sprinklers in the two lower stories which were saved without aid from the fire department, but the top story was completely destroyed (Fig. 2).

Sprinkler tanks are sometimes overflowed to prevent freezing, with the result that the entire structure is dangerously overloaded with ice. Tank towers are not designed to carry such a burden, which has caused the complete collapse of several structures. It is a part of the job of fighting fires beforehand to keep these tanks full and free from ice. Careful observations of tanks at various localities were made by the Factory Mutual Laboratory engineers for several winters. Temperature readings of the air and water were taken; and the amount of steam required to supply the radiation-loss was carefully measured. From these data and by means of a record of the lowest one-day temperature throughout the country, obtained from the United States Weather Bureau, the correct size of heater has been determined for tanks of various sizes and for any location in the country.

Trouble of this kind is not a serious problem to water-works men, because the circulation of water through municipal tanks and standpipes prevents freezing. We have, however, a record of an air-tight ice-seal forming in a standpipe at Collingswood, N. J. in 1900. When the water was drawn from the tank, a vacuum formed under the ice and the sides of the tank collapsed inward. The opposite effect, or bursting by internal pressure when water was pumped against a thick ice-seal, wrecked a standpipe at Defiance, Ohio.

Last summer, while making the usual water-flow tests at a plant in Cleveland, Ohio, one of our inspectors could obtain no water from the tank, which constituted the primary supply for the sprinklers. All valves were examined and found open. Other tests indicated that the base of the tank-drop was entirely obstructed. The clapper of the tank check was removed and the cover was bolted on again. Then, by means of the fire pump two or three pailfuls of scale was forced out through the 3-in. drain. Upon inquiry it was learned that the tank had recently been scraped and painted inside and out, and that when it came to removing the scale from the inside the painters adopted the easiest means of getting rid of it, — by dropping it down the tank riser.

Discovering troubles of this kind with the water supply, finding out what is the matter, and removing the obstructions, show the value of thorough flow tests as one of the important ways of fighting fires beforehand. Such tests may seem to some of you a waste of water, but the amount used is but a small fraction of what would be needed if a fire should occur that had to be fought with hose streams instead of by means of automatic sprinklers, which are able to extinguish fires with a minimum of water.

But even a good water supply and clear pipes are not enough. The water must be always instantly available. Last June, a large tee in an important supply main at Central Falls, R. I., broke at about eleven o'clock at night. The pressure in the mains dropped to almost nothing, and Pawtucket and Central Falls were without water for four hours. Fortunately no fires occurred during this period, but about 7 million gal. of water escaped from the reservoir. By three o'clock in the morning, the break had been isolated and the pressure restored, except in a small locality, which was without water for thirteen days. During this time, the automatic sprinkler system at the Pawtucket Spinning Ring Company was supplied by a line of hose connected into the riser drain and carried under the railroad tracks to a hydrant at an adjoining plant (Fig. 3).

There is no supply for automatic sprinklers so satisfactory as a good public water system. It is so reliable that we think of it as infallible; but sometimes it fails. Only this morning I received a letter from one of our inspectors in Newark, N. J. I would like to read it to you:

At two o'clock in the morning of September 6, 1927, a 24-in. main of the Commonwealth Water Company of Summit, N. J., broke in Millburn and impaired water service

in seven towns near Newark. Repairs were completed and service was restored at five o'clock in the afternoon of the same day. The cause of the break is not known.

West and South Orange, and Irvington were without water fourteen hours, during which time factories having automatic sprinkler systems maintained fire protection by secondary water supplies from tanks and fire pumps. The Irvington fire department made arrangements for an emergency connection to the Newark water system in case of a serious fire and had chemicals on hand for fighting small fires.

At nine o'clock, or four hours after this main had been repaired, another break occurred at a joint in a 20-in. main in the Canoe Brook Pumping Station at Summit. This break was caused by excessive pressure used while endeavoring to replenish the storage depleted by the first break. Repairs were completed and normal service was finally restored the next morning at three o'clock.

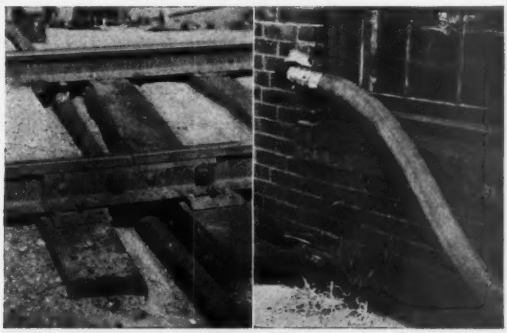

FIG. 3. — AN EMERGENCY SPRINKLER CONNECTION.
During a continued local interruption of the public water supply, sprinklers at the Pawtucket Spinning Ring Company were supplied by a line of fire hose laid under the railroad tracks and connected into the riser drain, with the supply taken from a hydrant still in service.

You probably hear of accidents of this kind in your own cities and neighborhoods, but in our work we experience a great many, because our plants are scattered throughout the United States and Canada. We have prepared a little leaflet containing a record of about three hundred interruptions and failures of public water supplies. In twelve of these instances fire broke out simultaneously with the interruption of the water supply.*

In addition to failures of water mains, we occasionally hear of an interruption of service at the pumping station. At the Mansfield, Ohio, pumping station last June, lightning wrecked a transformer supplying power to centrifugal pumps at this and two emergency stations. The resulting fire completely destroyed the roof and damaged the auxiliary steam pumps beyond repair. Electric pumps were out of service twelve hours, until temporary wiring could be strung. There was no reserve storage, so that the water supply was crippled as soon as the fire broke out. Fortunately, the station was situated at a low point and all the water remaining in the

*The Factory Mutual Fire Insurance Company will be glad to furnish a copy of this pamphlet to anyone interested.

piping was available for pumping engines. This made it possible to extinguish the fire before it entirely destroyed the building.

Lightning also crippled the pumping station at St. Hyacinthe, P. Q., not long ago, and simultaneously started a fire at a plant which we insure. Employees attempting to use small hose were much surprised to find no water, and although the sprinklers opened one after another, they were worthless. The mill fire pump was started and furnished the necessary water for two large hose streams, which checked the fire before the public water supply was restored.

Experiences like these show the value of a secondary water supply.

Four New Bedford mills have their yard systems interconnected in order to provide an adequate secondary water supply. Twelve fire pumps, located in several different power plants, can supply 56 hose streams. The city water alone can furnish 21 good streams. At Lawrence, Mass., a similar but larger system was installed a few years ago by means of a 16-in. interconnecting main, through which 25 pumps can concentrate 120 first-class fire streams at any one of the plants as a protection against a rather bad fire exposure.

To make it possible for these unlimited secondary supplies to supplement the capacity of the public water system, to provide adequate pressure for hose streams, to insure continuous fire protection by providing a duplicate water supply, and at the same time to properly safeguard the purity of the public water, the double check-valve system was devised.

A cross-section of the double check-valve arrangement is shown in Fig. 4. The tests for determining that these check-valves are tight are simple and can be made in a few moments at any time as follows:

First, close the outside gate valve, shown at the left of the cut. Second, open the test cock between the closed gate and the first check. The pressure gage, not shown, connected to the closed space thus formed, should drop to zero, and the second gage between the checks should drop about 10 lbs., as the outside clapper settles on to its seat when the pressure under the clapper is removed. Third, open the test cock between the clappers and the test gage connected to this same space drops to zero. The third or right-hand gage remains steady. This test proves that both checks are tight. Fourth, close both test cocks and *open the main gate valve again*, leaving everything in normal condition.

A new type of fire for the fire-protection engineer to fight beforehand has resulted from the rapid development of pyroxylin lacquer for finishing automobile bodies, furniture, and miscellaneous articles. The deposit of lacquer dust which accumulates in spray booths and in the ventilating pipes leading from them is a serious fire hazard. To demonstrate the danger, we staged a test by throwing a glowing cigarette butt into a spray booth having a layer of lacquer dust on the floor. A small cloud of white smoke indicated the beginning of the decomposition of the lacquer deposit. Then enormous volumes of the smoke poured from the booth, and soon burst into flame, shooting out at the full size of the booth opening.

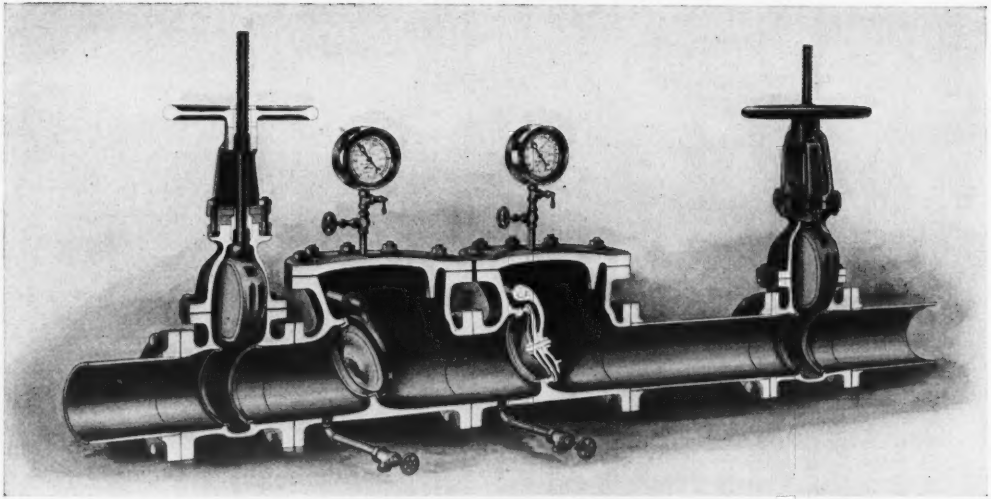

FIG. 4. — INTERIOR OF A SET OF DOUBLE CHECK-VALVES.
Showing relation of gages to clappers and to drains used for testing.

Imagine now a factory devoted almost entirely to this spraying process on a large scale, and you will have some conception of what occurred at the Briggs Automobile Factory in Detroit last April. You may remember that the newspapers carried front-page headlines telling of this severe explosion and fire, in which two men were killed outright and twenty died of burns. Twenty-six engines, 6 ladders, and 3 rescue companies responded to this fire.

It is only fair to state that this building was equipped with automatic sprinklers, but a violent explosion, which is supposed to have resulted from the ignition of a cloud of lacquer dust, broke one or more of the large pipes supplying the sprinklers, putting them out of service at the start. The fire then spread rapidly through unprotected door and wall openings, and completely destroyed the building, with a loss of about $2 000 000. By closing the sprinkler control valves, the water pressure and supply were conserved for the hose streams, by means of which the remainder of the plant was saved.

In spite of an occasional instance of this kind, in which a sprinkler system is overpowered, the effect of automatic sprinkler protection upon the fire loss ratio has been remarkable. The loss per hundred dollars at risk in several thousand industrial plants in America, from 1850 to 1875, which was the period before automatic sprinklers were in use, ranged from twenty to thirty cents; and then during the period from 1875 to 1895, when sprinklers were being installed, first in rooms of hazardous occupancy and later generally throughout the plants, the loss per hundred dollars steadily declined to about five cents. From that period to date, when sprinklers have been in general use in these plants, the loss ratio has not only continued at this low figure but is slowly decreasing. Of course, the entire credit for this reduction cannot be given to sprinklers alone, because fire departments have improved in efficiency, public water supplies have been extended and strengthened, and the science of fire protection generally has advanced. Nevertheless, the automatic sprinkler is probably the greatest single factor in reducing the fire loss in manufacturing properties.

The business man who erects a building or factory of good construction and protects it with automatic sprinklers is a better citizen than the one who builds a fire trap, without protection. The employees of the first man are safer, his business is more likely to be stable, and he will make less demand upon the fire department and water works.

Automatic sprinklers, however, are not applicable to all conditions. For example, a paper mill, worth ten or twelve million dollars, can be protected by automatic sprinklers, and yet $2 000 000 worth of logs stored in the yard during the summer months in piles 50 to 60 ft. high to insure continuous operation during the winter, cannot be protected by automatic sprinklers. Imagine, for example, on a hot summer day when the surface of the log pile is dry, sparks from a passing locomotive landing on top of the pile and starting a fire. You can readily appreciate what a difficult and

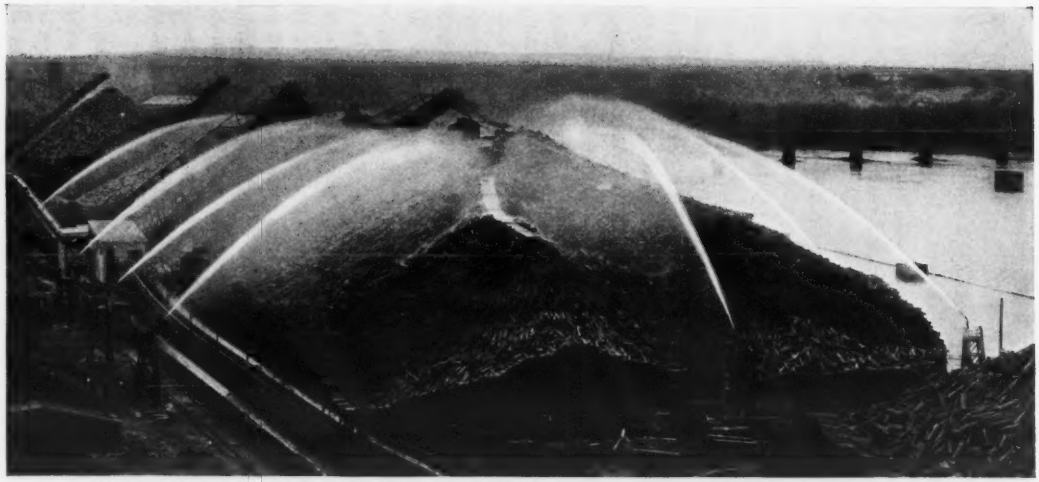

FIG. 5. — A DELUGE OF WATER FROM MONITOR NOZZLES.

Nearly 5 000 g.p.m. are being discharged through seven monitor nozzles with 1¾-in. outlets. Note that monitor nozzles are practically unattended. A large crew of men would be needed to handle the same amount of water from hose streams, and valuable time would be taken in laying the lines.

hazardous undertaking it would be for men to attempt to climb up over the logs with a line of hose. Unless water is applied at the very start, it is almost impossible to check a fire in one of these piles, and no ordinary hose stream can reach the top of the pile from the ground.

The sparks and embers drop down into the pile. The air filters in through the spaces between the logs and maintains combustion in the very center while the water from the hose streams is largely shed from the surface. This process goes on when once started, burrowing deeper and deeper until the entire pile is on fire. Later on, the pile resembles a mountain of live coals, which it really is, and when the fire has reached that stage, it is impossible to extinguish it and the pile burns down to a fringe of charred logs.

Although automatic sprinklers cannot be utilized to protect this valuable log-pile storage, the Factory Mutual engineers have worked out a highly effective protection by means of monitor nozzles capable of concentrating powerful streams on any part of a pile. The log storage is subdivided into units of 10 000 to 20 000 cords each with 100-ft. clear spaces between them. The ends of some of the piles are provided with concrete barriers to define the clear spaces which should be maintained between the piles. Clean conditions prevail in the yard, and concrete houses are used for the motors driving the conveyors, all with a view of reducing the fire hazard to a minimum.

The monitor nozzles are spaced around the piles at intervals of about 150 to 200 ft. and are interspersed with hydrants for supplementary protection. If the watchman patrolling such a log yard should discover a fire, he can proceed instantly to one of these nozzles without having to call for help. Without spending any time whatever to lay hose, he can direct one of these nozzles toward the fire, and by merely opening a valve can throw a powerful stream on the incipient fire in a moment or two. And then leaving this stream directed on the blaze, he can go to another nozzle and apply a second stream, all within a very few moments. While his part in extinguishing such a fire would be a very important one, nevertheless the fire would have been largely fought beforehand, i.e., when the fire-protection engineer developed this method of protection and the management installed it.

Some of these monitor nozzles are located at ground level and others are on towers to reach over the sides of the pile which may be "corded up" ten to twenty feet because of limited yard room. Figure 5 shows a number of these powerful streams in action at the same time, supplied by centrifugal pumps of large capacity.

Just one more thought in closing: Many people think of a fire loss merely in terms of the property damage, often entirely overlooking the fact that the indirect loss due to interruption of business and consequent loss of profits may be far more serious to the owner than the direct property loss.

This is particularly true when a fire interrupts some key process upon which the whole production of the plant depends.

New England manufacturers need all their profits now as never before. The fire-protection engineer and water-works engineer both can assist New England manufacturers in conserving their profits by helping them to fight their fires beforehand.

DISCUSSION.

GEORGE W. BOOTH.* I agree entirely with Mr. Mowry in his statement that automatic sprinklers are by all means the most effective fire protection that has ever been devised. They do, however, require attention from time to time, just like any other piece of equipment or machinery, valves, hydrants or pumps. The man who follows up the inspection service of these different pieces of equipment needs to be, as Mr. Mowry can tell you, quite a wizard at finding out what the trouble is.

Our own work in the National Board of Fire Underwriters is more directly concerned with municipal fire protection than with individual plant protection. You all know that you will find the same troubles with your municipal fire protection that Mr. Mowry has described regarding individual plant protection. Tests made from time to time are the best means of finding out whether conditions are as they should be; a man following that work becomes experienced to the point where he can determine quite readily what the probable cause of any apparent discrepancy is, and he can then trace it to its seat, find out what the trouble is and remedy it.

GEORGE A. KING.† I would like to inquire what Mr. Mowry considers the proper way to install fire-protection pipe for sprinklers in a business district, in the main street of the city. What arrangement of valves should be placed in the street and how can they be controlled by the water department, so that if a serious fire occurs and the riser breaks off the whole water system will not be crippled?

MR. MOWRY. In our work, it is universal practice to have the water company install a gate valve on all connections to a building as close as possible to its own main, under its control; then an indicator post at the curb, if possible, or if not, then inside of the building, under the control of the owner. If there were a fire in the building and the inside valve were not accessible the city valve could then be operated through the gate box and the connection at the main could be shut off.

MR. KING. In one fire we had recently, the valve was near the wall of the building; the wall fell over and covered up the valve; and the supply of water was discharging through the riser.

MR. BOOTH. I would like to suggest that in the case of a connection with a street main it is well to put the indicator valve near the main at a

*Chief Engineer, Committee on Fire Prevention, National Board of Fire Underwriters, New York, N. Y.
†Superintendent, Water Works, Taunton, Mass.

point where it will not be covered by falling walls, if there are such, — to put it at one end of the building, where the wall is likely to stay in. In that way you are surer of being able to get at the valves in the street than when they are put opposite the middle of the building where a falling wall may cover them.

GEORGE F. MERRILL.* I want to ask Mr. Mowry if he does not think it is the best practice to have the controlling valve at the main on all services.

MR. MOWRY. Yes, I do. In fact, I go so far as to say that any source of supply of anything, whether it be steam, water, air, or anything else, should have a valve at the point of supply, at the reservoir or at the supply main. I think it is very good practice.

STEPHEN H. TAYLOR.† There is one point that has not been brought out, which is sometimes advisable — in fact, almost always where a plant is dependent upon the city water supply only, as is the case in New Bedford. When we put in the supply, we install in the main on either side of the supply a valve which is paid for by the mill. In case of shutting off the street main we shut the valve on the side of the connection where the break is. This insures that the plant will have city pressure, except when the trouble is between the two valves where the connection takes off, a distance of perhaps four or five feet. I think, in installing these sprinkler connections, it is well to encourage the owners of property to do that for their own protection, and it adds so many more gates in your main pipe, thereby shortening the sections.

J. E. GIBSON.‡ There is one question I would like to ask Mr. Mowry. Have the Factory Mutual Companies established a rule as to the location of private hydrants about a mill building?

We have had recently in Charleston two fires where the hydrants have been located so close to the building that when the engine companies responded they could not get to the hydrants. I have criticized quite a number of layouts within the last year or two from that standpoint. The hydrants have been located too close to the buildings for service in case of fire.

MR. MOWRY. We prefer, whenever yard room is available and whenever local conditions will permit, to have the hydrants well away from the buildings. But there are many times when a steep embankment, a coal pile or some other obstruction will not permit placing hydrants far enough away. Then they must be put at the best places available.

MR. GIBSON. In the Charleston case, a ten-acre plot was available in which to locate the hydrant, but they set it about 45 ft. from the building. The mill was a fertilizer manufactory; and it caught fire about midnight; and by the time the engine companies got there, there was a serious fire. The wind happened to be in the right direction to cover the hydrants, so that the fire company was powerless.

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*Ware, Mass.
†Superintendent, Water Works, New Bedford, Mass.
‡Manager, Commissioners of Public Works, Charleston, S. C.

A representative of one of the factories came to me within the last six weeks and told me that his hydrant was set within 50 ft. of the building. I objected to this distance and advised him to go back about a hundred feet.

MR. MOWRY. You can't do that up this way very often; we don't have sufficient distances.

MR. GIBSON. I know there are conditions where it can't be done, but, when it can, it seems to me as if getting too close to buildings is just as objectionable as not having any hydrants at all.

MR. MOWRY. I think you are right. We work along those lines, taking into account the character of the building and the nature of the occupancy. All the factors have to be considered in any given case. We can't apply a definite rule in all cases.

W. S. CRAMER.* In Lexington, the chief of the fire department requires that indicator post valves be set at the curb. There have been one or two places where it was objectionable to do so. In that case we used a small box, much like an iron meter box, and brought an extension up to it so that the hydrants could be handled through it. All of our apparatus is made with the same nut that our hydrants have, so that the fire chief can use his own discretion about turning them on or off.

We use universally the tap T on the main rather than a cut and the ordinary T. With this, there is no chance of a failure in case of break or loose connections anywhere that might blow out at that point. It ensures the valve holding all the time.

MR. MOWRY. In Lawrence, we have a great many indicator posts along the curb line, and in other communities this is also the case. At times we use the O. S. & Y. valve in a concrete pit in the ground with a manhole. Some cities will not permit anything along the curb.

HENRY T. GIDLEY.† I would like to ask Mr. Mowry if he has had any experience with water hammer caused by the installation of a sprinkler system.

MR. MOWRY. Yes, we have had many cases of moderate water hammer, — usually in the operation of hydrants. When a hydrant on a high-pressure system is closed too quickly, water hammer is set up at times and has caused leaks. In some cases, due to the operation of a fire pump, there is also some vibration; but we are not troubled very much with water hammer.

We had an instance this summer which we have not entirely explained, but it happened, I believe, in this way: we think that the clapper in the check valve from the tank was partly hung up due to insufficient clearance or corrosion around the clapper; when the fire pump was tested, a back-flow was set up into the tank until the velocity became great enough to slam that clapper down onto the seat; in doing so, it started a rather bad leak. We have no other explanation for the severity of that water hammer. Such experiences, however, are not very frequent.

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†Treasurer and Superintendent, Fairhaven Water Company, Fairhaven, Mass.

FIELD ENGINEERING SERVICE OF THE NATIONAL FIRE PROTECTION ASSOCIATION.

BY FRANKLIN H. WENTWORTH.*

[*Read September 13, 1927.*]

The National Fire Protection Association is an instrument, one might say, of civic awakening and civic action. Its work is not confined to the individual risk; it takes into its purview the good of the entire nation by the prevention of fires, the cities as units as well as individual property.

HISTORICAL.

For thirty years the National Fire Protection Association has been attempting to reduce the fire waste of America. Thirty years ago fire protection was still a rudimentary art. The Factory Mutual Fire Insurance Companies were just beginning their engineering work under the stimulation of Edward Atkinson, and the stock insurance companies were beginning to look with interest upon the automatic sprinkler system and its possibilities; but there were no established standards for automatic sprinkler practice; there were no standards for hydrants and fire hose nor for fire-fighting devices and materials of any other sort. Fire-protection engineering as such was unknown. If a building caught fire, it usually burned to the ground, unless the local fire department managed to extinguish the fire.

The National Fire Protection Association was formed by a group of men interested in the engineering aspects of fire prevention. There is no partisanship in the Association. There are no differences between the stock company engineers and the mutual company engineers who are represented on the Association's committees, except those of engineering judgment. The Association is after the best engineering opinion without regard to methods of underwriting, and it is not interested in rates at all.

Standards for Fire-Fighting Equipment. The first standard evolved by the Association was the standard for sprinklers. At that time practice varied throughout the country. A manufacturer in Connecticut might consult the local fire underwriters and might be advised to adopt a certain layout for his sprinkler system, obtaining a certain rate by so doing. The same manufacturer might also have a plant in New Jersey, or in Pennsylvania, exactly like his New England plant, but if he proceeded to use the same sprinkler layout he might not get the same recognition from the insurance companies, because the New Jersey or Pennsylvania authorities

*Secretary, National Fire Protection Association, Boston, Mass.

might demand something quite different. Nobody knew authoritatively what pipe sizes should be used, how large the riser should be made, or how the sprinkler heads should be distributed. Everybody had a different opinion. The National Fire Protection Association was formed to determine and establish the best engineering practice in automatic sprinkler installations.

The Association called together the engineers of the country who were familiar with the subject; after two or three years of friendly dispute and argument a standard was evolved, adopted, and published. Having accomplished this task, the Association proceeded to make standards for other equipment, until now the National Fire Protection Association has thirty technical committees. One of these has charge of the National Electrical Code and follows the many rapid changes in electrical practice, registers the hazards involved, determines upon allowable practice, and revises the code at regular intervals. Electrical practice follows the requirements of this code quite generally throughout the United States and Canada. This piece of work alone justifies the existence of the National Fire Protection Association.

The study of electrical hazards, however, is only one of some thirty items that are regularly considered by the technical committees of the Association. Invention and development in all the fields of mechanics are rapid, and the committees have to keep abreast of them in order that their standards may be trustworthy. The standards evolved by the Association are published by the National Board of Fire Underwriters and are distributed gratuitously to the public.

Public Education. About fifteen years ago, one of the Boston members of the Association called to the attention of the Association the fact that, while it had been at work for a dozen years making regulations by which the fire waste might be checked, the fires were actually increasing in geometrical progression. This fact awakened the Association to a new sense of its responsibility. It became clear that if it really was a national fire-protection association, it was the duty of the Association not only to make regulations by which fire waste might be checked, but also to educate the American people to adopt and follow the regulations that had been established.

The Association, at that time, had about $200 in its treasury with which to educate the American people. It was decided to spend all of these funds in one attempt. A leaflet was prepared on the economic significance of fire waste, showing its amount, and its distribution. This leaflet was sent to every daily newspaper in the country — and it went into the editorial wastebaskets from Maine to California. The editors didn't know anything more about fire protection than did the average man in the street. Some thought the undertaking was an insurance project; some wrote that if the fire insurance companies wished to reduce the fire waste the columns of their papers were open at so much per inch, never realizing that the

Association was merely trying to do good for the country; others thought the leaflet was an advance bulletin of fire-apparatus advertisements.

But there was one newspaper, the Boston *Herald*, the Sunday editor of which, Mr. Buxton, called on the Association and enquired into the nature of its work. He was amazed at the seriousness of the problem and expressed his desire to coöperate. Upon his invitation the Association prepared an article, and Mr. Buxton had his staff artists surround the text with sketches of flames and of firemen carrying babies down ladders; all quite in accordance with the custom of Sunday supplements. The article went out to a waiting world, and about twenty newspapers that would not take anything from the Association took the articles from the Boston *Herald*, published them and commented on them — some of them editorially.

The Association then wrote to these editors, enquiring whether they would publish bulletins occasionally; and thus developed a press bureau that now supplies about two hundred and fifty newspapers with material on fire prevention. That was our first gesture at public education. Next the Association began the publication of various bulletins. It advocated fire-prevention days, the appointment of fire marshals, and the teaching of fire prevention to the children in the schools. Every possible avenue that was open was taken to call the attention of the people to this important problem. Yet little progress was made.

One of the members of the Association was the National Association of Credit Men. Mr. Charles E. Meek was secretary of this association, and he conceived the idea of getting at the public through his organization. The National Association of Credit Men has local organizations in the different cities of the country, and the secretary makes a yearly tour of these cities. He invited the Secretary of the National Fire Protection Association to go with him, to present this matter of fire waste and to break through the existing inertia. The writer, as Secretary of the National Fire Protection Association, agreed to go with him.

Publicity was prepared and the country was covered in about sixty days, starting from New York to the Northwest, thence down to San Diego, along to Denver, to Texas, Atlanta, and back to New York. The Mayor and the Governor, the leading engineers and architects, the city engineers, and all others who should actually be interested in this problem were invited to attend the meetings. Publicity was well handled, and ever since that time the Association has had the constant and enthusiastic coöperation of the credit men of the country. An impetus was thus given through this member organization to the educational program of the National Fire Protection Association. If the Association wanted a fire marshal, there was a credit man in the State right behind the movement; if teaching of fire prevention in the schools was to be inaugurated, the credit men would help to do so. All matters of public education were backed up, and are backed up today by the credit men of the country.

Thus, during the last fifteen years, the Association is gradually getting into the consciousness of the people the fact that a fire loss of $500 000 000 a year is of tremendous economic importance. It is a loss that no country, no matter what its resources may be, can stand continuously and remain prosperous. Slowly the best minds of the country are awakening to this fact. Most of the people, however, still do not understand it. They insist on thinking that it is a fire insurance matter, that, if they are insured, they have done all that is needed.

The Fire Tax. The people must be made to understand the economic significance of the fire loss. If they could be taught in a very simple, elementary way, as the Association tries to do; if every man and woman could be shown that all stocks of goods are insured, that the buildings housing them are insured, and that the insurance is added to the cost of the goods; that when they buy a hat, a pair of shoes, a suit of clothes, or anything that goes through the channels of production and distribution, they pay a fire tax concealed in the cost of the goods;— then they would better understand the true situation.

In most cases this fire tax is cumulative. Take cotton as an example. Cotton is insured in the sheds in the South; it is insured in transportation, in the warehouse, in the textile mill, and in the department store. Throughout its course, cotton bears an accumulating fire tax, and whoever buys cotton goods pays the tax concealed in the cost of the goods. It is a form of indirect taxation that is not appreciated or otherwise realized.

If you pay a personal property tax, you draw your check for it; this fact registers. You suffer the mental agony of being separated from your money. But if it is a tax that merges with the cost of everything you eat and everything you wear, you do not suffer because you do not know about it. You may cry out against the high cost of living and against the struggle for livelihood, as our people often do, but, unless we trace the cause, unless we see what it is that is impoverishing us, unless we get other people to see it, we will not mend our ways and will not care about fire protection. We must get at the public consciousness. We must continue to educate our people, as the Association is doing, by every avenue that is open.

In spite of all these efforts our fire waste last year was greater than it has ever been in the history of the country in any year not marked by a great single conflagration. The loss last year was $560 000 000. What is there in our social and industrial life that permits us year after year to sustain without protest, without thought, such a frightful loss? It is because we are obsessed by the notion that the insurance companies pay the loss. But how could they, and remain solvent? They are merely collectors and distributors of the tax. They are not touched at all; the burden falls on the person who buys the product. The insurance companies not only pay for the losses, but they must pay their expenses as going concerns, must pay interest on their capital, taxes and all the expenses of their business. That is their problem, but it is our problem too.

Field Engineering Service.

That brings us to a consideration of the field engineering service of the National Fire Protection Association and the thought that gave rise to it. The impoverishing effect of fires is national; we all pay our share. But every fire itself is local; it starts in a specific place. That thought gave rise to the idea two years ago that the Association had arrived at a point where it could take a step that it had in mind for the last fifteen years,— to take its engineering experience directly to the cities and to awaken them to local action. An appeal was made to the membership of the Association for enough money to employ two competent men who might be sent out to certain cities whose fire record had been bad over a period of years. These men were to make a study of the causes of the fires and to bring a civic spirit to bear on the problems. They were to go into a city, to select the leading citizens, to lay before them the record of their city and to ask why that city should rank so high in fire losses.

The work undertaken has been successful. The Association begins, in a sense, where the insurance companies leave off. Very little is done with individual risks. The main conflagration hazard of the city is given chief attention. If a city block burns it goes off the tax list, and the other parts of the city must make up the amount that is lost to taxes by the city through the fire. This hurts business locally. It is a matter much bigger than the insurance problem; it is a civic matter. The Association has no difficulty in presenting this matter effectively to the leading men of cities, and in getting them to make a study of their local conditions and to inaugurate improvements that will bring their city out of its bad standing.

The National Board of Fire Underwriters makes reports on cities of over 20 000 inhabitants. The National Fire Protection Association begins where these reports leave off. It creates the civic sentiment to study the reports,— which are now regarded with indifference by too many communities,— to study the defects pointed out, and to see what can be done to correct the losses from certain causes. The Association makes a special study of the conflagration hazards of the city blocks that are marked in the reports as black blocks. The details of these blocks are redrawn and particularized to show, for example, where window openings might be protected, where protected door openings might prevent a sweeping fire, and a study is made in an endeavor to eliminate the conflagration hazards of the city. It is not the individual fire, it is the fire that gets outside the building in which it originates and that spreads to other buildings that causes the big losses. Even in New York, with its brick and stone buildings, over four hundred fires last year got outside the buildings in which they originated.

Yet fire prevention is an easy thing; it is a simple matter of engineering. But desire precedes functioning, the scientists tell us. We must want a thing before we can accomplish it, and we must awaken our people individually to see what can be done.

In many cities of the country the fire departments are not functioning properly. It is astonishing to find how many large cities have no municipal inspections by the fire department. There are great cities with bad fire records and no fire-prevention bureau, no inspection at all, no drilling of the men, no fire towers and no instructions. The men sit around the fire houses, and then go out and perhaps give their lives in fires that should not have occurred. It is amazing to find the number of cities in this country that do not use their fire departments intelligently and that have no interest in their departments whatever. They like to see the pictures of the fireman in the papers, and to see the chief go by in his red wagon. They don't know anything about his job at all; they don't know whether he is efficient or not. They do not go to see his apparatus. They take no interest in fire prevention, because they do not realize that it is a civic matter; that every man, woman, and child is paying for the fire waste.

Fire Loss. The magnitude of the fire loss can be appreciated by studying the following tables.

TABLE 1.

ANNUAL PER CAPITA FIRE LOSS BY STATES, 1926.
Cities over 20 000 Population.

New England States.

State.	Number of Cities.	Loss.
Massachusetts	38	$4.45
Maine	3	3.38
Rhode Island	6	3.09
Connecticut	13	3.07
New Hampshire	3	2.76
Vermont	1	2.23
New England	63	3.90

Other States.

Texas	11	$3.51
Indiana	18	3.07
New York	30	3.06
Michigan	15	3.04
Pennsylvania	31	2.99
Illinois	23	2.85
California	14	2.61
New Jersey	22	2.51
Wisconsin	11	2.33
Ohio	29	2.18
United States	377	3.35

TABLE 2.

ANNUAL PER CAPITA FIRE LOSS IN NEW ENGLAND CITIES WITH HIGH FIRE RECORDS, 1922–1926.

City.	Year.					Average
	1922.	1923.	1924.	1925.	1926.	
CONNECTICUT:						
Danbury	$6.42	$1.69	$4.64	$4.54	$1.87	$3.83
New Haven	3.53	2.90	5.43	3.83	4.18	3.97
New London	1.40	5.60	3.51	7.85	6.63	4.99
MAINE:						
Portland	9.24	2.84	4.40	6.05	4.87	5.48
MASSACHUSETTS:						
Beverly	1.54	2.73	6.24	5.87	2.32	3.70
Boston	4.34	8.18	6.19	6.97	6.59	6.45
Cambridge	5.74	3.85	7.15	3.07	5.38	5.03
Chelsea	5.20	10.61	6.24	4.45	7.89	6.87
Everett	1.95	7.14	2.88	8.01	5.57	5.11
Gloucester	3.01	2.51	5.07	7.30	11.28	5.85
Haverhill	6.46	8.56	5.03	6.22	11.85	7.62
Leominster	3.50	9.45	3.49	14.09	5.23	7.15
Lowell	4.10	5.44	8.66	3.13	14.43	7.15
Lynn	3.59	4.13	11.71	4.40	4.78	5.72
Peabody	14.25	1.57	8.56	13.19	9.11	9.33
Revere	2.62	5.67	4.74	4.29	6.26	4.72
NEW HAMPSHIRE:						
Concord	13.37	11.14	4.91	4.90	4.17	7.71
370 U. S. cities	3.57	3.42	3.37	3.53	3.35	3.44

TABLE 3.

ANNUAL PER CAPITA FIRE LOSS OF LEADING CITIES, 1922-1926.
(Figures from National Board of Fire Underwriters.)

City.	Year.				
	1922.	1923.	1924.	1925.	1926.
Boston	$4.34	$8.18	$6.19	$6.97	$6.59
Chicago	2.66	1.97	2.23	3.75	4.86
Buffalo	4.61	5.24	5.01	5.79	3.84
New York	3.88	3.31	3.16	3.21	3.66
Pittsburgh	3.29	2.23	3.58	3.43	3.37
St. Louis	4.42	3.45	4.15	3.95	3.09
Baltimore	5.52	2.18	2.45	2.66	3.07
Philadelphia	2.69	4.11	2.38	3.23	2.93
Detroit	2.21	3.99	3.17	3.16	2.73
Cleveland	2.70	2.18	2.41	2.97	2.46
Los Angeles	1.54	1.67	1.61	1.47	1.77
370 U. S. Cities	3.57	3.42	3.37	3.53	3.35

TABLE 4.

FIRE LOSS IN BOSTON METROPOLITAN AREA, 1926.

Cities comprising 90 per cent. of the Population in the Area defined as Metropolitan Boston for State Census Purposes.

City.	Population (thousands).	Total Loss (thousands of dollars).	Per Capita Loss, 1926.
Arlington	30	$54	$5.78
Boston	793	5 231	6.59
Brookline	47	129	2.74
Cambridge	120	645	5.38
Chelsea	49	387	7.89
Everett	43	239	5.57
Lynn	103	492	4.78
Malden	55	79*	1.44
Medford	51	147	2.88
Melrose	21	34	1.60
Newton	54	119*	2.21
Quincy	63	164	2.60
Revere	35	219*	6.26
Somerville	100	257	2.57
Waltham	37	61	1.66
Watertown	30	117	3.89
	1 631	$8 374	$5.13

*Insurance loss only.

Reduction in Fire Loss. With these figures in mind, what better method of attack upon this problem can be applied than the plan that has been devised? It has been tried out in a number of cities that had an exceedingly bad fire record. Of course one city may show a reduced loss by chance, but if losses are reduced in a dozen cities, as has been the case, the result means something. The following records may serve as examples:

The per capita fire loss in Grand Rapids was as follows: 1923, $8.03; 1924, $6.90; 1925, $4.98; 1926, $1.90. A steadily declining loss is therefore apparent.

Norfolk, Va., for ten years had a loss of about $10 per capita. In 1923, the loss was $4.91; in 1924, $3.04; in 1925, $2.52; in 1926, $1.79. A few years ago, when it had this terrific record, the Association went to Norfolk with a little group of engineers and inaugurated a series of meetings and conferences which it can be proved resulted in the decline shown.

Indianapolis, at one time, was one of the worst cities in the country, but last year had a loss of but $1.82 per capita.

The loss in Detroit was $3.99 in 1923; $3.17 in 1924; $3.16 in 1925; $2.73 in 1926.

The present reduction over 1923 in all these cities is very great, and it is simply because they have awakened civically to the importance of this matter.

Future Work. Having done this work for three years with two engineers, the Association is now making a campaign to secure larger funds

from industry, whose problem it is, because industry pays the bill. The Association is showing industry how fire waste may be checked by this direct and sensible procedure through public education and the application of standards.

The Association is seeking to secure money to employ enough engineers to properly cover the country, to awaken the civic consciousness in the cities that have bad fire records; to induce them to make a study of their hazards, to use their fire departments intelligently, to clear up the rubbish, to control their gases and oils, to look after their hazards generally and to look after arson. One of the latest developments in the fight against arson, is the creation of an arson squad in the fire department. For this purpose the police department places an officer or two, at the beck of the fire chief, and every fire, the cause of which is obscure, is investigated. This idea is spreading rapidly in the United States. Detroit notably has reduced its number of incendiary fires by investigations of this type. All the things that promote fire waste can be taken into account by local organizations that are created by the field engineers of the Association.

The Association is showing the leaders of industry the terrific economic loss, the enormous burden that is being carried in a $500 000 000 loss, 80 per cent. of which is preventable.

A committee has been created with the fire chiefs and with the American Water Works Association, with the idea of bringing the fire chiefs and the water-works men closer together. In some places they are not in harmony. The fire chief must be made to understand the water-works man's problems, and the water-works man must learn to understand the fire chief's problems, so that a spirit may be created that shall help the local committees which are being organized to function effectively. Only thus will be checked this shameful loss of $500 000 000 a year, 80 per cent. of which is preventable.

Discussion.

Hugh McLean.* Mr. Wentworth has certainly presented his side of the case in a very, very able manner. I never knew an insurance man who was not able to do it.

Mr. Wentworth. Why do you call me that, sir? I have nothing to do with fire insurance.

Mr. McLean. That is what they all say. Every time you ask for a conference with insurance men about reduction of rates or the prevention of fire losses, you are able to get an audience with them, and they will send a man to talk to you about it; but you never have an opportunity to talk to the man that makes the rates.

I am interested in the reduction of this great loss, as a citizen. From the civic point of view, I can speak for our own city that we had a gentleman on a mission similar to that which the last speaker represents, who

*Water Commissioner, Holyoke, Mass.

came before us and formed a fire-prevention committee, and we also have had fire-prevention week. But it is astonishing that in the last thirty years we have not been able to reduce this tremendous fire loss; it has been increasing all the time, notwithstanding that we have supplanted the old horse-driven apparatus with big, high-power motor-driven machines. Then of course as regards the mains: The water departments in every municipality in Massachusetts have been put to enormous expense in the last ten years in almost duplicating their mains, to comply with the requests of the insurance companies. The fire department per-capita costs have nearly tripled in the last ten years, to meet the requirements of the insurance companies. Notwithstanding, the fire losses have been increasing all the time. But we have not heard of any fire-insurance companies going out of business on account of not making enough profit, while the manufacturers, who have to enter into competition in the manufacture and distribution of goods, are daily obliged to leave New England on account of alleged high tax rates. We have had this campaign going on for a long while; but has the fire loss been decreasing?

A little while ago, I attended a meeting in Washington and listened to a very able discussion along this same line. The Governor of Georgia was there, and he was proud of Albany, Ga., because it had reduced the fire loss more than any other city in the country. He was so proud that he presented the mayor of the city, who asked the fire chief to stand up so that the people could see the man who was responsible for the reduction of fire losses. The Governor of Kentucky also came, along with the mayor of one of his towns, Owensboro, Ky. There were others, too, and they were all proud of their accomplishments. It was stated that as a reward for increased protection, for lessening of the causes of fire loss, there had been awarded some $30 000 in returned premiums to the insured in Albany, Ga., and in Owensboro, Ky.

What incentive is there in the average Massachusetts city to conserve property and reduce the fire loss if there is no reward? It seems to me that the insurance companies have to look at the matter from still another angle. Instead of giving protection to every Tom, Dick and Harry, and penalizing the rest of us who are careful in guarding our properties, they should not take in any and all kinds of risks regardless of the consequences. The Associated Industries Companies are very careful in selecting their risks. They will not take a risk unless their requirements have been complied with. Go to some shops, and you will see in the corner the old wooden box where all the sweepings are put together with waste paper, rags and refuse. There ought to be a metal box for the purpose, and there ought to be a metallic lid over the top of it at all times. But the majority of the insurance companies do not require that they take such precautions; they insure everybody and everything. Then they take the ablest men on their staff and send them out to lecture. They want the business interests to subscribe for the expense of their campaigns.

The insurance companies have seldom gone out of business, and they are amassing fortunes, many of them. Then they tell us that this fact should not be taken into consideration, that these fortunes are taken out of past profit. There is no appeal from an increase in insurance rates, but if there is an increase in the tax rate in a town, or in the water rates, what a mighty howl goes up immediately about the rise in water rates or the rise in tax rates! In these days of our careful study to reduce the cost of government it is hard to allow the insurance companies to continue raising their rates without apparently making the effort that they should make to prevent losses.

Somehow or other, there is a feeling among the average man who is insured which he expresses by saying: "Well, I am insured; I don't care what happens." European cities do not have these tremendous losses through great fires. They have trained the people to prevent them, and the insurance companies won't insure people that they are doubtful about.

I know the rates are very unequally applied in many cases, and there is a great deal of dissatisfaction. I know of one particular place, twelve miles from a hydrant, where the rate is 36 cents a hundred dollars, and I know of another place within 100 yards of an engine house where it is $1.35. There is a great deal of unequal distribution of insurance rates; but when you want to see the insurance men, you can see and talk with all of them except the man who makes the rates.

I think the time has come — it is here — when the business men of this State should insist that the matter of fire insurance should be put on the same basis as the public utilities, so that there shall be some responsible person in this State delegated by the Legislature or the Governor to whom appeal can be taken as to the right of insurance companies to make rates at will. I think an organized effort along such lines is now taking place and that proper legislation will be asked from the Legislature this coming year.

CHARLES W. MOWRY.* The statement that the fire tax rate has been mounting higher and higher every year is somewhat misleading, as the valuations have also been increased, so that the actual fire tax rate has been going down per thousand dollars. It used to be something like $4 or $5 a thousand, but now it is about $2.50. The fire tax rate is the actual loss per thousand dollars of value. The reduction began about the time that our serious efforts at fire prevention were started, so that we ought to be encouraged by our efforts at fire prevention rather than discouraged.

Mr. MCLEAN. I hope Mr. Mowry does not take it that I am discouraging fire prevention. I am heartily in favor of it, and as far as my own property is concerned, I never had a fire. I see to it that I do what I ask others to do. But when I see unnecessary fires, I think it is the duty of the insurance people to stop them, and they can be stopped, if the insurance companies will only take the bull by the horns.

*Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

MUNICIPAL WATER AND SEWERAGE COSTS IN MARYLAND.

BY ABEL WOLMAN.*

[*Read September 14, 1927.*]

Theoretically there should be no mystery, and certainly no difficulty, in determining how much any commodity costs any consumer. Furthermore, and again theoretically, it should be just as simple to find out how much a consumer pays for a given commodity. If every consumer paid for each unit of his commodity directly to the agent delivering it, at the time of delivery, without subsequent, more or less painless, extraction of additional payments, this paper would be relatively unnecessary.

Aside from the fact, however, that "there is no line of business that has such great and unreasonable variety in its schedules of charges as will be found in water works,"[1] there are so many devious, weird and attractive auxiliary methods of producing revenue for municipal utility financing, that the preparation of this paper takes on the aspect of a fairly colorful detective story, in which the search for the culprit is no less interesting than in fiction merely because the obstacles are both statistical and human. I do not suspect, of course, that in the small State of Maryland there is any greater complexity or variety of municipal utility financing than in Massachusetts, for example. The present inquiry is restricted to Maryland, for my ignorance of its methods is least, and life is much too short to extend the search into wider but more dangerous fields.

The problem of determining actual, as distinct from theoretical, costs of sanitary facilities is not new. It has been a matter of interest to the State Department of Health for many years, because the development of such facilities has been predicated upon the fact that in action, if not in conscience, to the public a dollar is more important than a death. The necessity for accurate utility costs, therefore, has long been apparent and our efforts have likewise been directed toward stimulating sanitary programs upon financial bases, which seemed to us in general to be more intelligent and equitable than those currently in use as a heritage from the "mauve decade."

In reviewing the past ten years of these activities and the present status of municipal financing, the outstanding characteristics of the earlier programs give ample testimony of the eternal struggle between the forces of equity and logic, on the one hand, and political expediency, ignorance and ineptitude, on the other. It should be stated, however, that in earlier years, as today, political expediency is not condemned by the author where it represents a concession to strong and intelligent public demand, rather than an obvious inept, ignorant and frequently unnecessary play for popular

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support. For, after all, the most perfect syllogism of municipal financing should fail, if it is so complex, so mysterious and so lacking in conviction as to carry with it an intelligent popular opposition.

In some respects, the theoretically perfect financing procedure starts as a failure because it is a departure from the familiar, and a change connotes to the citizen a danger. The familiar method may be ridiculous, but he recognizes it. Hence, the writer's pessimism, for example, about ever seeing a profound change in water and sewer financing in Baltimore, even though the opportunities and necessities therefor have been apparent to some observers. Here, as in other governmental enterprises, fiscal structures in earlier days were rarely the results of conscious creation; they rarely kept pace with social, economic, geographical or technical facts. Although most of them were largely matters of historical accident, they are, of course, commonly accepted now by the average citizens as natural, normal and logical structures. The promise for the future lies practically, therefore, with those communities or groups of communities which start fresh and may initiate principles of functioning that parallel at least those methods showing more equity and logic to all concerned.

These variations in financial methods fortunately have occurred in Maryland, both through design and through chance. The picture which the Maryland costs present, therefore, should be interesting, even though, at first sight, confusing. The data run the gamut of every form of payment for capital investments from the universal one of general property taxation to the specialized one of front-foot assessment, with intermediate combinations of all current forms of financing. In some instances two diametrically opposite procedures are in force in two political entities separated only by an imaginary line, popularly described as a "political boundary." As wide apart as the principles are in so small a State as Maryland, there are interesting and frequently valid explanations of the differences, although sometimes the historical reviewer may be driven to explaining them as due to the relative humidities of the atmosphere rather than to any apparent differences in causative facts.

A Logical Plan for Payment.

It is helpful in reviewing the data, later to be presented, to outline briefly the principles of financing which the State Department of Health has suggested for the past ten years. Since Morse and Wolman[2] have set these forth in detail elsewhere, they are only recapitulated here to assure coherent discussion of other phases of this problem.

It has been assumed that any plan for meeting both capital and operating costs of water and sewerage systems should provide for rigid separation of public and private benefits and for fairly complete differentiation between fixed and operating charges. Following these two primary principles, in general, the installation of water supply and sewerage systems in Maryland was designed to be paid for by a combination of general property tax, an-

nual front-foot assessment during the term of the bonds issued, cash payment for house connections, meter service charge, sewer service charge and water consumption charge. The allocation of these charges was proposed in the following general form.

1. Fixed Charges:

a. *General or Property Tax* pays for that part of the cost of water and sewer construction which may be assumed to be of value to all the taxable property. Such property would normally include reservoirs, pumping stations, treatment works, supply and outfall lines and sizes of mains in excess of those normally used locally for water distribution and sewage collection.

b. *Front-foot assessments* are ordinarily expected to provide the revenue for paying the cost of construction of those water and sewer lines abutting upon the particular properties and which are of special or individual value to such properties. Ordinarily such assessments would cover the costs of a 6- or 8-in. water main or an 8-in. sewer line. In all instances, under the plan recommended by the State Department of Health, such front-foot assessments represent the interest and sinking fund on the costs indicated above. These funds are provided through bonds, for terms usually from thirty to fifty years.

c. *House connection charge* is usually a cash payment and covers the cost of the water or sewer connection from the main to the property line. In some instances it may be continued over more than one year. Some consideration has been given to distributing this charge over the entire term of the bonds.

2. Maintenance and Operation Costs:

d. *The meter service charge* covers the ready-to-serve portion of the operating cost.

e. *The water consumption charge* provides for the fluctuating costs of maintenance and operation of the water-supply service.

f. *The sewer operating charge* provides for the fluctuating costs of maintenance and operation of sewerage services. It may be included in the two water charges.

It should be clear from the above analysis that these arrangements for supporting municipal utility costs are consolidations of the more familiar procedures of either general taxation, special assessments or rates based upon service. The use of any one of these methods to the exclusion of either of the others has been discarded on the score that no single one of them meets all the requirements of equity or logic in the development of municipal systems.

As a result of the application of these methods of financing, from 1918 to the end of 1926, $2\frac{3}{4}$ million feet of water and sewer lines have been constructed in the State of Maryland, for which the greater portion of the

payment has been met through the continuing annual front-foot assessments. It may be stated at this time that, barring minor disabilities and necessary adjustments for particular localities, all of which will be discussed later, the procedure of financing water-main and sewer-line construction by the front-foot assessment method has proved eminently successful. As far as the author is aware, this application of the opportunity of distribution of charges between various classes of benefits and properties has been worked out in no instance on as wide a construction scale as in this State. There are, of course, excellent examples of extensions to existing systems being carried out on the front-foot assessment plan, but this procedure is distinctly different from the programs herein outlined as applied to newly created systems of large size.

The statistical material which the writer presents herein illustrates the wide variation in practice which exists and will probably continue to exist in the State in the financing of municipal systems. As pointed out before, the variations are the result, in some cases, of historical precedent and antagonism to change and, in other cases, of efforts to meet the distinctly variable psychologies in different areas of the same State. An apparent fear of general taxation in one area prevents the application of general taxation as one source of revenue, whereas in other areas in the same State, and not more than forty miles away, the reverse procedure is accepted. We have the picture likewise in one undertaking, where the entire accounting and technical procedure had been formulated, looking toward the establishment of both front-foot charges and general taxation for the payment of the municipal water and sewerage system and was then completely overturned within twenty-four hours in favor of financing the entire program by general taxes. The underlying psychologies, the perspectives as to political expediency and an honest difference of opinion, stubbornly maintained in one section regardless of the practice or experience in another, are all non-technical phases of water-supply and sewerage situations that offer an attractive field for study. They cannot be ignored in such a paper as this, because in practice they control, regardless of the scientific and logical attributes of any scheme of financing.

What Do the Systems Cost?

A surprising amount of energy may be expended by the curious individual who takes it on himself to search out the paths through which the various contributions from the taxpayer and the consumer pass in finally reaching the funds supporting these municipal utilities. There are relatively few instances in which those contributions by the taxpayer and the consumer are obviously being devoted to water and sewerage purposes. This frank state of affairs does exist in a number of instances, particularly in the newly formed metropolitan districts where, of course, the revenues are all devoted to these sanitary purposes. In a municipality like Baltimore, however, it is not always immediately apparent whether or not the

PLACE.	RESIDENTIAL FRONT-FOOT ASSESSMENT, WATER & SEWER		DIRECT TAX PER $100.		SERVICE CHARGES.	
	Rate.	Total.	Rate.	Total.	Water, Total.	Se To
		1		2	3	
Baltimore County Metropolitan District.	$.30	$15.00	...	...	$6.80 City-owned Mains $2.40 County owned Mains	No to Tow $11.2
Hagerstown.	...	...	26c.	$7.80 13.00	...	$10
Baltimore.	...	...	6c. Wat. 18c. for San. Sew. Only Tot.=24c.	$7.20 12.00	...	
Elkton.	...	...	11.5c.	$3.45 5.75	...	
Frederick.	...	"D"	...	...	$3-Bath 3-Toilet =$6.00	"I
Cumberland.	$2.00 per foot for 50′ Lot =$100.00. Flat Charge Sewers Only Prob. Equivalent $.12	$6.00	...	...	...	..
Salisbury.	...	...	34c.	10.20 17.00	$4.00	..
Washington Suburban Sanitary District.	$.26 "F."	$13.00	5c.	$1.50 2.50	$4.00	..
Anne Arundel Co. Sanitary District.						
1-Overlook Dist.	$.28	$14.00	5c.	$1.50 2.50	...	..
2-Glenburnie Dist.	.27	13.50				
3-Linthicum Dist.	.26	13.00				

"A" — Cost when water service is on flat rate. "B" — Cost when water service is metered
"C — Does not include payments on new loans. "D" — No sanitary sewers in Frederick
"E" — No sewer-service charge as yet; will approximate $5.00 per house. "F" — Maximu

ICE. DES.	Sewer. Total.	Fire Hydrant Rental per Year (each)	Water Consumption Charge.	1925–1926. TOTAL ANNUAL COST OF WATER AND SEWER SERVICE 50' LOT-CONSUMP.-40 000 GAL. YEAR. Assessment. $3 000.	$5 000.	CONNECTION CHARGES. Water.	Sewer.	Total.
	4	5	6	Add Columns 1–6 Inc.		7	8	7+8
	No Rate to Date Towson = $11.25 Yr.	$24.00 Probable Yearly Cost per Property = $1.00	$.20 per 100 c.f.-City-owned Mains = $10.66 $.15 per 100 c.f.-County-owned Mains = $8.00.	$33.46 on "E" City-owned Mains $26.40 on County-owned Mains.	$33.46 on "E" City-owned Mains $26.40 on County-owned Mains	$18 or $20, Depending on Paving.	$15 Minimum charge. $1 per ft. in excess of 15'.	$33 or $35
	$10.00	...	$.30 per M. Gal. per month up to 3 333 Gal. "C" = $12.00	$29.80	$35.00	$700 plus $.20 per ft. say $13.00	$15.00	$28.00
	...	...	Aver. $12.00 for Flat Rate. $2.00 per 1 000 c.f. for first 5 000 c.f. = $10.66	$19.20 "A" 17.86 "B"	$24.00 "A" 22.66 "B"	$20, 24, or 28 Depending upon Paving.	...	$20 $24 or $28
	...	...	Flat Rate = $21.20 $.25 per M. Gal. for first 5 000. $.20 per M. Gal. for next 5 000 Quarterly, $9.00 Yr.	$24.65 "A" 12.45 "B"	$26.95 "A" 14.75 "B"	$10.00 to Curb.	$10.00 to Curb.	$20.00
	"D"	...	$.25 per M. Gal. per 6 months up to 25 000 Gal. = $10.00.	"D" $16.00 Water Only.	"D" $16.00 Water Only.	Approx. $2.00	...	$2.00+
	...	...	Flat Rate = $27.50 5 000 Gal. or less per month @ $.25 M. = $10.00, Min. Charge = $12.00.	$33.50 "A" 18.00 "B"	$33.50 "A" 18.00 "B"	$15.00 for Meter in City. $10.00 for Tap Outside City.	$15.00 30.00	$30.00 in City, $40.00 Outside.
	...	...	Flat Rate = $15.00. $.20 per M. Gal. = $8.00	$29.20 "A" 22.20 "B"	$36.00 "A" 29.00 "B"	...	...	...
	...	...	$.18 per M. Gal. = $7.20	$25.70	$26.70	$35.00	$35.00	$70.00
	...	...	Flat Rate = $15.00 $.40 per M. Gal. for first 10 000. Quarterly = $16.00.	1 {$30.50 "A" 31.50 "B"} 2 {30.00 "A" 31.00 "B"} 3 {29.50 "A" 30.50 "B"}	1 {$31.50 "A" 32.50 "B"} 2 {31.00 "A" 32.00 "B"} 3 {30.50 "A" 31.50 "B"}	...	...	...

metered.
derick — combined sewers in part of area.
Maximum, some lower.

so-called water rents fully provide for the water costs. Inasmuch as no sewerage service charge is in vogue in Baltimore city, the search for the cost of such service to the taxpayer leads into the complications of the general tax bill, in which records one must tread warily.

After considerable manipulation, search, discussion and adjustment, there is presented in Table 1 a fairly accurate picture of the municipal water supply and sewerage costs of somewhat over one million people in the State of Maryland. This tabulation gives a characteristic picture of the state of affairs for practically the entire urban population of the State, because a large proportion of the remaining five hundred thousand persons residing in the State are scattered in the communities of semi-urban or rural character.

Several features of the data in Table 1 should be pointed out in more detail. Attention is called to the fact that the procedure of payments shown for the Baltimore County Metropolitan District is decidedly distinct from that used in the adjacent territory in Baltimore city. We have the anomalous situation in these two groups of two populations being supplied by Baltimore city water and separated from each other by nothing more than a purely imaginary line. Three systems of payments are in use in the two areas: (1) the general taxation and water rent plan in Baltimore city, (2) the more detailed plan in the County Metropolitan District on Baltimore City-owned mains; (3) the Metropolitan District plan on mains owned by the Metropolitan District. The financial plan inaugurated in Baltimore County appears to the writer to be the only one which would have made it possible to provide water and sewerage facilities in an area having a scattered population and virtually completely encircling the Baltimore city boundary line. Although the direct property tax has not yet been used in the Baltimore County Metropolitan District, it is probable that it will be instituted as further progress on the construction program is made and a greater area is covered.

In Baltimore city the situation, particularly in the newly annexed territory, is not satisfactory, from the standpoint of an adequate fiscal program, because the large bond issues for water-supply and sewerage purposes, made necessary by the demands in these growing areas, are being financed out of general taxation. The major portion of such taxation is naturally falling upon the taxpayer of the old city whose benefits therefrom are, to say the least, somewhat remote.

The experience in Salisbury with the attempt to finance the new water-supply and sewerage systems on the joint basis of front-foot assessments and direct taxation is of special interest. In this case, local authorities are of the feeling that the detailed accounting and technical service, necessary to set up a financial scheme predicated upon front-foot charges, is far more costly than warranted by the benefits to be derived from the choice of this particular method. In view of the fact that there may actually be, in the administration of such projects for communities under, say, 15 000 in

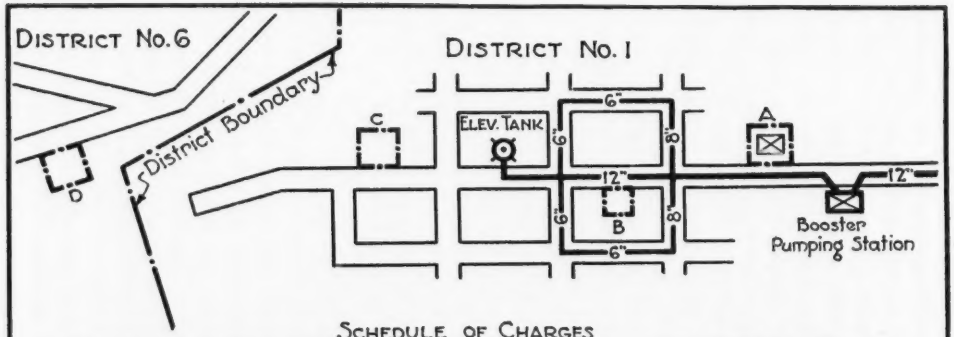
population, a diminishing return in the use of the front-foot method, we have in recent years provided in most legislation for small towns the alternative of general taxation or a combination of the procedures already described above. There is no escape from the fact that the assessment procedure involves a number of details of administration that may be too cumbersome for the small community, although its advantages, for equity of burden, are so great that it should not be discarded without careful consideration. Although the amount of effort is great in collecting the necessary information[3] as to the ownership of all taxable property, its quantity, character and value, the systematic recording of that information, the analysis of the information, the equitable application of the results and the compilation of a comprehensive assessment roll, the results in fair charges and incidentally valuable data are likewise great.

Where our concern is not only that of establishing a sane and economical procedure of financing, but also of having that procedure fully understood and completely accepted, we have always been confronted with the necessity of clarifying these concepts in a manner likely to produce satisfaction. The objections to the front-foot method are in most instances of a minor character, but they create a great deal of opposition unless these objections are promptly and completely eliminated. We have found that the graphical presentation of these facts in the form shown in the accompanying figure is decidedly helpful.

Refinements in the application of the front-foot procedure, such as gradations in front-foot benefit charges for different classifications of properties, always offer opportunities for manipulation, adjustment and opposition. Such classifications are inherently legitimate and practically essential, although we know of no single, greater source of irritation than ill-advised calculation of front-foot assessments, where errors or differences in judgment as to classifications, benefits, etc., are unavoidable. These confusions and antagonisms are not surprising, when it is remembered that any scheme of financing is not susceptible to complete mathematical analysis with the probable errors reduced to a minimum. All such allotments require judgment. The fallibility of human judgment is well known, and the contentiousness of one or two taxpayers is just as familiar.

The data in Table 1 give emphasis to the fact, long known to waterworks men, that few commodities are as cheap as these municipal utilities. Regardless of the system of payment in use, the total ultimate annual cost to the consumer for water and sewerage service is remarkably low. It is still a mystery why these costs are subject to so much antagonism in most cases. The average man's cigars cost twice as much each year. The real values of the two groups of commodities are hardly comparable.

Although the total annual costs in each of the instances in Table 1 are low, the inequalities in financial methods are best shown by comparison of the two columns under property valuations of $3 000 and $5 000.



SCHEDULE OF CHARGES

SYMBOL	SOURCE OF ANNUAL REVENUE	ALLOCATION OF BENEFIT	BASIS OF CHARGE	APPLICATION OF REVENUE
a	front-foot assessment	individual	cost of 6" main	fixed charges
b	increase in tax rate	district	cost-of-mains-over-6" plus pump. sta., elev. tank, etc.	fixed charges
c	water consumption	individual	actual water used plus meter service charge	maint. & operating charges

Note: "a" varies for different kinds of properties

PROPERTY CLASS	ANNUAL PAYMENT
A	a+b+c+d (connection charge)
B	a+b
C	b
D	0 (until Dist. No. 6 is under constr.)

MARYLAND STATE DEPARTMENT OF HEALTH

GENERAL PLAN
FOR
MEETING WATER AND SEWERAGE COSTS

Abel Wolman
Chief Engineer

July 19, 1927

Some Reflections on the Front-Foot Assessment.

Practically all of the sanitary districts in the State of Maryland have passed through the Court of Appeals for testing one phase or another of their financial plans. Some of the decisions and the associated aspects of these tests are of general as well as of local interest. In practically each case it has been decided that the Public Service Commission of Maryland has no jurisdiction over matters involving the administrative functions of the sanitary commissions, covering such matters as the classification of property, the design of water and sewerage facilities, etc. In the case of the Washington Suburban Sanitary Commission and the Anne Arundel County Sanitary Commission the amounts of general taxes and of front-foot assessments are subject to review by the Public Service Commission. This is not, however, the case in the Baltimore County Metropolitan District.

Determination of Amount. Some difficulty has been occasioned through the failure of administrators to determine, at the beginning of the project, an amount for the front-foot assessments that, during the later development of the project, would not be found to be insufficient to meet the demands of outstanding charges. Some confusion exists at this time in the Court of Appeals decision, in the case of the Washington Suburban Sanitary District, as to whether a front-foot assessment, once established, may later be increased by the Sanitary Commission. The commission has endeavored to meet this situation by new legislation in 1927 in which the specific amount of the front-foot assessment has been established by the State Legislature.

In the Baltimore County Metropolitan District adjustments of the front-foot assessments from year to year are provided by law, and the Court of Appeals, in 1927, decided that such adjustments are within the province of the administrative authorities as functions delegated to them by the State Legislature. In other words, the establishment of such front-foot assessments has been interpreted by the Court of Appeals as simply an extension of the taxation powers of the County Commissioners assigned to them under the provisions of the State Constitution by the State Legislative Assembly.

Public Notice and Hearing. One of the most controversial features in the application of these methods has been in the question as to what public notice and hearing should be provided when front-foot benefits are allocated. Inasmuch as the existing legislation provides that the front-foot assessments and the service charges shall be collected "by an action for debt or by a suit in equity to foreclose the lien," the Court of Appeals has determined that this provision in itself includes all the notice and hearing necessary to satisfy constitutional requirements. The taxpayer or property owner, therefore, presumably has no more right to be heard as to the amount of the assessment than he would have to be heard upon the

question as to how much the annual tax levy for a local area should be. This decision is founded upon the fact that the Legislature itself has determined all the questions in these acts, which may be described as judicial in character, and has left to the Commissioners only the matters of fact and not of judgment. This view, plus the provision of a method by which the taxpayer is heard in court, has been the basis of the decisions by the Court of Appeals.

It should be pointed out here, for clarity, that in most ordinances for paying for extensions by the front-foot assessment method, the assessment can only be made without notice or hearing when an opportunity for the taxpayer to be heard in court is provided. In those instances where the tax constitutes a lien on the property, collectible in the same manner as other taxes upon real estate, namely, by summary process and sale, public notice and hearing always must be provided.

Has the property been benefited? Everyone is familiar with the contention of the individual who, actually or supposedly, feels that his property has been benefited little or none and, therefore, an assessment is unjustified. This contention the courts have ordinarily dismissed as untenable. Cooley[4] summarizes the principle briefly, as follows:

"It has been repeatedly decided that the legislative act of assigning districts for special taxation on the basis of benefits cannot be attacked on the ground of error in judgment regarding the special benefits, and defeated by satisfying a court that no special and peculiar benefits are received. If the legislation has fixed the district, and laid the tax for the reason that, in the opinion of the legislative body, such district is peculiarly benefited, its action must in general be deemed conclusive."

The United States Supreme Court, in *Houck* v. *Little River Drainage District*,[5] stated: "When local improvements may be deemed to result in special benefits, a further classification may be made and special assessments imposed accordingly, but even in such case there is no requirement of the Federal Constitution that for every payment there must be an equal benefit." And further, in *Miller and Lux* v. *Sacramento Drainage District*,[6] "the doctrine has been definitely settled that in the absence of flagrant abuse or purely arbitrary action a State may establish drainage districts and tax lands therein for local improvements, and that none of such lands may escape liability solely because they will not receive direct benefits."

Summary.

Certain general conclusions appear from the above analysis of the municipal water-supply and sewerage costs in Maryland. They are presented here without further comment.

1. A wide variety of methods for financing municipal sanitary facilities is in use.

2. The origins of such variations lie in unexplained historical precedent, concessions to political expediency, efforts to meet the demands of the

psychologies peculiar to the localities and, in a considerable number of instances, in the desire to supply an equitable and logical procedure.

3. Opportunities for profound changes in methods of finances are rare in any community where such utilities have been available for any considerable number of years. The obstacles are temporary inequalities that such changes may produce and the unfamiliarity and, hence, the danger of newly suggested procedures.

4. Regardless of the procedure in use, municipal costs for water supply and sewerage are lower than the costs for practically any other commodity supplied to the consumer. One of the amazing features of this review is that it makes apparent the fact, frequently stated, that the consumer obtains modern water-supply and sewerage facilities at an annual cost less than what he would ordinarily expend for any other luxury or necessity.

5. Although this is the case, opportunities for inequality of distribution of these burdens are exemplified in the data presented in the body of this paper. The details of such inequalities have not been stressed, but they should be apparent to the careful reader.

Acknowledgments: The author is indebted to his assistants, Mr. George L. Hall, division engineer, and Mr. J. R. McComas, assistant engineer, for the painstaking review and statistical calculations of the data shown in Table 1. The author is particularly pleased to record the hearty coöperation of the municipal and sanitary district officials who furnished the material used to compile Table 1.

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[1] Hazen, Meter Rates for Water Works, p. 12.
[2] A Plan for Meeting Water Supply and Sewerage Costs, *Engineering News-Record*, vol. 86, No. 22, June 2, 1921.
[3] Buck, Municipal Finance, p. 316; MacMillan.
[4] On Taxation, vol. 2, p. 1208, 3d ed.
[5] 239 U. S. 254, 1915.
[6] 256 U. S. 129.

DISCUSSION.

A. E. WALDEN.* The writer has read with great interest the author's paper on Municipal Water and Sewerage Costs in Maryland. Since May, 1924, the Metropolitan District Commission has been installing water mains and sewers in a district having an area of 234 sq. miles, under a scheme for financing the system similar to the one the author has described, with the exception, that to date all the assessments have been on a front-foot basis. This method of assessment for financing a project is not new, as it has been applied in the West to drainage and irrigation projects, in one large city to subways and in some cities to street improvements.

We have been operating about three years on a front-foot assessment basis, owing to the fact that the Commission considered it best to assess the

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cost in this manner, until such a time as they would have more information as to what portion of the cost should be considered strictly a benefit to the abutting property and what part was undoubtedly a benefit to the sub-districts or district, as a whole. This general cost would be spread over the entire district. At present we are determining the taxable basis in the sub-districts, as distinct from that of the county at large, for the purpose of distributing the total costs between the combined front-foot assessment and a general property tax, if found advisable sometime in the near future.

The Metropolitan Commission has expended a little over three million dollars out of an issue of bonds amounting to over five million dollars. The installation of water and sewer facilities has resulted in an increase in real and personal property in 1926 in the district of seven million dollars over the average of the preceding three years. The real and personal property is increasing at about the same rate, notwithstanding the fact that there has been somewhat of a slump in real-estate activities during the past year.

Since May, 1924, the Commission has installed over 125 miles of water mains, varying in size from 6- to 16-in., and about 80 miles of sewers, varying in size from 6- to 20-in. The average cost per foot for water mains, including some Class "C" pipe, was $3.15, and for sewers, including all house connections, $4.06.

Financing House Connections. House connections for sewers at this time are charged for at $1 per ft. for half the street width, the measurement being taken from property line to property line and the charge being uniform to each abutting property owner. The minimum charge to each property owner is $15, taking a 30-ft. street, the unit on which the charge is based. One dollar per foot is added for any greater width of street. The balance of the construction cost in excess of $1 per ft. is carried in the regular front-foot assessment. A certain amount of working capital will have to be provided for the installation of future house connections, after the initial collecting system has been completed. The future property owner will probably pay a greater portion of the cost for future house connections.

Meters and meter boxes are paid for by the Commission and the charge is carried in the construction cost, with the exception of the meters installed on city-owned mains. When a reduction in the charges for service rendered and water consumed on city-owned mains is made, a small assessment will be made on the abutting property owners to provide for the cost of these meter installations.

Service connections for water are paid for in advance by the property owner. The minimum charge is $16 for a $\frac{3}{4}$-in. service, $4 being added for opening an improved street.

On Metropolitan-owned mains there is a meter service or ready-to-serve charge of 60 cents a quarter for a $\frac{5}{8}$-in. meter, and a proportional increase in the charge for larger sizes. The water-consumption charge

provides for the cost of maintenance and operation of the water service, and the sewer-operating charge provides for the cost of maintenance and operation on a yearly basis.

The installation of water mains under the Metropolitan Act has resulted in a direct benefit to the residents in the district, inasmuch as there has been a reduction in the cost of water to those consumers, on Metropolitan District owned mains, of a little over 25 per cent. and a slight reduction to county residents on city-owned mains. Both of these classes of consumers, as the systems extend, will undoubtedly receive further reductions. Fire hydrant rentals have been reduced from $45 yearly to $36 on city and to $24 on Metropolitan District owned mains.

Experience with Front-Foot Method. The application of the front-foot assessment and the method of its determination were not generally understood and, therefore, created some agitation and friction, due to the fact that some property owners desired to escape payment of any assessment, even though they were directly benefited; while others have contended, and with some justness, that the assessment should not be entirely on the front-foot basis. Any other method of assessment on a new project, such as this, would have created, however, the same friction, owing to the lack of data as to exemptions to be made and the proper classification of the property to be served. As the method became more generally understood, this opposition practically died out. In many instances, citizens assumed two feet of assessable frontage for each foot of pipe laid. This is not the case, however, if consideration is given to the fact that the cost of crossing streets and alleys and the frontage of triangular and irregular shaped lots must be borne by the front-foot assessment as a whole. The assessable frontage obviously lies between one and two front feet for each foot of pipe laid. The average in the Metropolitan District at this time is about 1.4 assessable front feet per foot of pipe laid.

In some instances prior to the Metropolitan program, in the subdistricts and in one small subdivision, assessments were made practically entirely on the value of improvements. The assessment on the land abutting on the sewer system being ridiculously small, and a large proportion of the total assessment being carried by the majority of the property owners having improved property, it was clear that neither the straight general tax nor the straight front-foot assessment was satisfactory when taken alone, but that the combined general property tax and front-foot assessment were preferable. It is the only method that presents a fair and reasonable restraint on those individuals who invest in idle property with a view of gain resulting largely from the activity of others. The existence of such undeveloped property increases the cost of the utility passing the premises.

A careful study of the conditions can only lead to the conclusion that, for any municipality, the most equitable way to distribute the cost of water mains and sewer installation is on a combined front-foot assessment and general property tax basis.

There is ample evidence that, where the assessment for the cost is in the general levy, or extensions are made and financed from the general levy or property tax, property owners who have already paid for their share of the cost of the original installation of a system of water mains or sewers, are never entirely relieved of the burden of this tax for future extensions, from which they receive little or no benefit. In addition, property owners in outlying districts will not receive the benefit of the water supply and sewerage system for many years. In the meantime they are compelled to pay, through general taxation, for benefits that they may never receive.

F. H. DRYDEN.* Salisbury, with a population of 10 000, an assessable basis of less than 11 million dollars, burdened with an inadequate, privately owned water-works system, serving only 800 homes, and a small combined sewer system covering less than one-third of the public streets, presented a bill to the Legislature in 1924, requesting authority to issue bonds for $550 000 to cover the cost of constructing a water-supply and sewer system in the city of Salisbury. This bill was passed during the same session, subject to the ratification of the voters. Prior to the election on this issue, a campaign was conducted to acquaint the voters with the advantages to be gained, and an attempt was made to show the ultimate cost to the taxpayers. This campaign resulted in the bond issue being carried by an eight to one majority.

The enabling act for this work provided alternate methods of financing: (1) Front-foot benefit charges, applicable to properties abutting on the improvement, and a property or general tax to cover the proportionate cost of the systems beneficial to all taxable property. (2) The straight general tax plan. The first of these two methods was accepted for our use.

The water-works and sewer systems were designed for an ultimate population of thirty to forty thousand, and the water supply, pumping station and equipment, and the trunk sewers were constructed on this basis, representing an expenditure of approximately $350 000, or two-thirds of the entire bond issue. The balance of the funds was used in building lateral lines to furnish fire protection to all sections of the city, and water and sewer service to 50 per cent. of the population. These conditions, together with the fact that the privately owned water company was acquired, and a number of existing sewers, constructed partly by individuals and dedicated to the city, were incorporated in the general systems, presented numerous difficulties in the division of charges between the general tax and the front-foot assessment.

The bonds covering this work were issued as thirty-year serial bonds, so maturing that the carrying charges approximated $35 000 annually. This annual charge was met during the first two years of the construction program by the interest received from local banks on deposits, and an addition of 10 cents per $100 on the general tax.

To carry into effect the front-foot assessment, it was necessary that

*Chief Engineer, Salisbury Water and Sewer Commission, Md.

all property frontages be measured, that the properties be classified as to their uses and that complete records be installed to care for property transfers, collections, etc.; which involved an expenditure of several thousand dollars. After numerous adjustments of figures, a schedule was worked out proportioning 20 cents per $100 to the property or general tax and a front-foot assessment for residential properties having both water and sewer improvements of 20 cents per front-foot and 33 cents for business or commercial properties, each having a graduated scale after the first 150 ft. A nominal charge for agricultural properties was included. These taxes and assessments were to continue during the life of the bonds. It was estimated that these charges would produce a revenue of $38 000 annually, which amount was required to meet the interest and retirement on the bonds and the maintenance of a collecting office. Notices of assessments were mailed during August, 1926, as required by the enabling act, and a time set for a hearing. At this hearing hundreds of property owners appeared, protesting on the matter of assessment for water mains and sewers constructed previous to this bond issue, although they had been acquired by the city. In numerous cases it developed that the property owner had paid a portion of the original construction cost. Others claimed they did not want the improvements and objected to the assessment. This hearing disclosed the fact that the front-foot assessment method of financing met with the general disapproval of the taxpayers, while comparatively no objections were made to including the entire cost in the general tax. The method of financing, therefore, was immediately changed and a total of 34 cents per $100 was added to the general tax in October, 1926. This tax is collected with the other city taxes by the city treasurer without additional cost, thereby effecting an annual saving of approximately $3 000 in office expense. It was the original opinion of those handling the financing of this project, that such an increase in the general tax would meet with considerable objections, but the fact that it was accepted generally, is partly explained by the benefits that were directly received by the taxpayers. These are as follows:

1. A 33–40 per cent. reduction in water rates, reducing flat-rate charges for the average home from $25 to $15 per year, and reducing meter rates from 30 cents to 20 cents per 1 000 gal.

2. The elimination of the $5 charge for tapping water mains and the $25 charge for tapping sewer mains.

3. Construction of water and sewer service pipe to the property of the consumers without charge.

4. The maintenance of water and sewer service connections in the public streets.

5. The elimination of the annual charge of $20 for each fire hydrant in service, also eliminating the charge to property owners for water used in fire service.

6. Reductions in insurance rates.

The records for the year ending June 30, 1927, show that the above projects have effected an annual saving of approximately $65 000 to the citizens and taxpayers of Salisbury; $40 000 of this amount representing the saving in fire-insurance premiums, brought about by a reduction of 20 per cent. in insurance rates for industrial and commercial properties.

The major portion of the construction of the original project was completed in the latter part of 1926. An additional appropriation of $200 000 was authorized by the Legislature in 1927, for the extension of the water and sewer systems. This issue was placed before the voters in May, 1927, and was passed with only 30 dissenting voters; which fact speaks for itself as to the general approval of this entire project.

The new water plant was placed in operation on July 1, 1926, at which time the old privately owned plant was abandoned. Upon assuming operation of the water works, the city placed into effect the reduction in water rates and elimination of certain charges, as enumerated above, and the elimination of the tapping service charges and hydrant rentals. After these marked reductions, the water-works system has been so operated that the report for the year ending June 30, 1927, indicates that the revenue from the sale of water is sufficient, not only to maintain and operate the water and sewer systems, but to meet annually the interest and retirement of the first $100 000 of the 1927 bond issue. It is thought that within three years the interest and retirement of the other $100 000 issue can be met by the water rentals.

ROBERT B. MORSE.* Advancement of the public welfare on a large scale, as far as sanitation and comfort, and perhaps health, are concerned, may be consummated most effectively through the installation and extension of water and sewerage systems in communities in which they either do not exist or do not cover all populous sections. The writer bent his efforts towards this end when he was chief engineer of the State Department of Health of Maryland for ten years previously to 1922. He felt that much good could be done by mass elimination of individual devices for water supply and sewage disposal and therefore did not limit the duties of his organization to supervising the operation of existing works and the examination of plans presented to his office. Mr. Wolman, the writer's successor, has carried on effectively this program of promoting the extension of water and sewerage service throughout the State.

No campaign of the above-mentioned nature can be broadly successful unless waged on a secure financial footing. Arguments concerning health, sanitation and convenience avail little — they are the intangibles, in the public estimation. If one can prove, however, the individual saving in expense for fire insurance, well-cleaning, pump repairs, disposal of refuse, etc., and can offer a method of financing the public improvements that will surely cost no more than the saving effected, the demagogue loses his stock in trade and the improvement program has greater prospect of success.

*Chief Engineer, Washington Suburban Sanitary District, Md.

In order to promote effectively the installation of new water and sewerage systems, therefore, it becomes of particular importance to establish a financial set-up that will be fair to the individual and burdensome neither to him nor to the credit of the community. That the individual expense, especially in these times of high costs, may not be too large, everybody benefited should pay, and pay in proportion to the benefit received. Likewise should the public treasury pay its way.

The subject treated so well in Mr. Wolman's paper is thus one of no little importance. The method he describes for meeting water and sewerage costs has some rather novel features, the writer believes. Its use by municipalities, and particularly by water and sewerage districts, in Maryland has been urged by the State Department of Health practically from the beginning of its effort to encourage the construction of water and sewerage systems. There has now been sufficient actual experience with this financial plan to prove that it is practical as to application and may be adjusted to local needs in such manner as not to become burdensome.

Pioneer among those adopting this plan was the Washington Suburban Sanitary District, an overlying municipality covering most of the suburbs of Washington that are situated in Maryland. This district, which has an area of 96 sq. miles and a population of approximately 50 000, lies in two counties and contains 16 small municipalities, together with a number of so-called special taxing areas, many unincorporated communities, and much undeveloped territory lying between and around the populated sections. Established by an act of the Maryland legislature in 1918, the district already has systems containing about 210 miles of water mains and 160 miles of sewers. There are approximately 9 500 water and 7 500 sewer connections. Only 53 miles of water mains and 60 miles of sewers existed in this area when the district was organized.

The affairs of the Washington Suburban Sanitary District are administered by a Commission of three men, two of whom are appointed by the County Commissioners of the two counties in which the district is situated (both of these appointments being upon recommendation of the State Board of Health), while the third is named by the Governor. The Commission issues its own bonds as required, without a referendum, and has all the powers usually granted to municipalities constructing and operating water and sewerage systems. It also controls plumbing work throughout the area.

All municipal and privately owned water and sewerage systems in the district have been purchased by the Commission and have either been incorporated into the comprehensive systems or else replaced. The total purchase price of systems acquired, as well as the cost of new construction, is met by the financial plan under discussion,— front-foot assessments and a small charge on the tax rate of the whole district.

Annual payment of the front-foot assessments during the whole life of the construction bonds (50 years) constitutes perhaps the most outstanding feature of the financial plan adopted. These charges are meant to repre-

sent the potential benefit properties received from the systems through being accessible to a water main or sewer and are laid alike on developed and undeveloped land abutting the pipe lines. They are somewhat higher, therefore, than the average cost per linear foot for laying lines of small diameter. Payment of frontage assessments over a long period of years, to cover a large part of the annual interest and sinking-fund requirements, results in a small unit charge which is in effect nothing more than a small, equitably allocated tax and is not burdensome even on the average comparatively long frontage prevailing in the district.

Surprising as it may appear, payment of the small annual front-foot charge has caused more popular misunderstanding and complaint than any other one thing relating to the Commission's work. The thoughtless property owner, multiplying his annual frontage assessment by fifty, protests that he is paying much more than the cost of the pipes passing his property; apparently not realizing that their cost is being met by a long-termed public mortgage negotiated by the Commission. When told that he may pay the whole assessment in one sum at the time of construction, or redeem it on a present-worth basis at any later date, his mind suddenly starts working, and it occurs to him that the Commission is able to borrow money for him at a much lower rate than he can for himself. As a result, practically no benefit charges have been redeemed.

The power to vary front-foot benefit charges annually, like an *ad valorem* tax, to suit construction costs and other variables, is highly desirable, so as to preserve uniformity in rate on a given class of property at any one time and to eliminate the necessity of varying the general tax rate widely from year to year. This power, as Mr. Wolman points out, has been passed upon favorably by the highest court in Maryland. When legislation seeking to establish the Washington Suburban Sanitary District was being drafted, the writer sought strenuously, but in vain, to have provision made for adjusting benefit rates from year to year, as might be found advisable. Instead, the act stated that no front-foot rate, once levied, was to be increased. This proviso has caused substantially all of the legal and financial difficulties that have befallen the Commission.

Early front-foot rates established by the Commission were too low as they did not allow sufficiently for the large amount of reconstruction work found to be necessary in connection with the acquired municipal and private systems, nor for the small receipts to be obtained during early years from long and expensive cross-country connecting pipe lines. So front-foot charges later levied were higher, thus causing a decided lack of uniformity in different sections of the district. In an endeavor to wipe out the deficit, without establishing too high a front-foot rate along newly installed pipe lines, or else increasing the general tax to an undesirable degree, the Commission amended the law, as it thought, so as to allow an advance in the lower front-foot rates already levied. Conflicting provisions, however, were left in the legislation, and the courts have denied the Commission

power to increase the benefit charge on any property. This has resulted in legislative acts allowing the Commission to pay for the construction of reservoirs, purification works, pumping stations and main supply lines through the water rates, which is not in conformity with the fundamental theory upon which the financial plan was based.

The Commission builds water and sewer connections as far as the property line, making a flat charge of $35 for a ¾-in. water service and the same amount for a 6-in. sewer connection, regardless of length or constructional difficulty. Meters are generally placed near the curb in settings of 4-ft. depth. The cost of the setting is included in the connection charge. Rates for larger water services vary with size of pipe.

Maintenance and operating costs of both water and sewer systems are met by a ready-to-serve charge, varying from $4 annually for a ⅝-in. meter to $360 for an 8-in. meter, and a water consumption rate varying from 18 cents per thousand gallons for the first 50 000 gal. used semi-annually to 9 cents per thousand gallons for all water consumed in excess of 2 500 000 gal. monthly. Public fire hydrant service is furnished without charge.

While the financial plan used by the Commission is not so adjusted as to be strictly in line with the findings of a detailed analysis proportioning the costs among the various classifications, it is sufficiently near mathematical accuracy to preserve the equities for all practical purposes, and perhaps as close to such accuracy as local conditions and prejudices will allow. Under this plan property not accessible to a water main or sewer is subject to a very small annual expense; undeveloped land along a pipe line bears a burden which is somewhat larger and which is sufficient to stimulate building; while the developed lots, though averaging considerably larger payments for the benefits of complete service, still are put to an expense usually amounting to only from two to three dollars a month, and the cost to many of them amounting to much less.

In spite of the usual difficulties besetting a new form of administrative body during the development of a large project, not the least of which has been a considerable public hostility fanned by misinformation and misunderstanding, the Commission has succeeded, during these times of high costs, in constructing and operating adequate water and sewerage systems in this extensive and thinly populated suburban area, where water mains and sewers are almost exactly twice as long per 1 000 people as in the average city of equal population, at an expense which results in charges and rates not burdensome to the average property owner and no greater than those prevailing in cities in which a large part of the water and sewerage systems was completed before the war. The writer believes that this could not have been accomplished except under a financial plan similar to the one adopted and that such a plan is especially fitting for municipalities installing new systems or districts establishing comprehensive systems for a group of communities.

MILTON J. RUARK.* The data and discussions presented by Mr. Wolman in his paper are instructive and suggestive. Realizing the enormous practical difficulties involved in establishing a new or rearranging on old system of paying for sanitary facilities, it may be readily seen how important it is to bring before the lay and the engineering public the problem of adequate financing. The discussion which Mr. Wolman presents is all the more interesting to the present writer, because of his long experience with the situation in Baltimore city. Although this experience is largely restricted to problems of financing a sewerage system for a population in excess of 700 000, there may be certain aspects thereof of interest to the readers of this JOURNAL.

It is my feeling that the construction of the sewerage system for the city of Baltimore would have been virtually impossible, under a system providing for payment by front-foot assessments. General taxation for this purpose, with all of its disabilities, was a familiar plan to most of the lay citizens. The introduction of an assessment program, upon whatever basis, would have required many years of educational propaganda, and no doubt would have deferred the installation of a sewerage system then already too long deferred in Baltimore city. Although the construction of this system might not have been impossible with the use of the front-foot assessment, it certainly would have been retarded.

It is an interesting fact, likewise, that the Baltimore sewerage system represents one of the few large installations which were practically new over their entire extent. A similar system is that of New Orleans, incidentally supported by general taxation. It is my further impression that, in such an undertaking as this, the detailed data essential for carrying out the front-foot assessment plan would result in a considerable overhead cost which might not be justified.

There certainly is no doubt that the continuation of the general taxation plan in Baltimore city, with successive annexations of new and highly developed territory without adequate sanitary facilities, will probably result in imposing an added taxation burden on some of the property holders of the old city. Here again, efforts made by the writer during the past ten years to interest civic bodies and municipal authorities in both the front-foot assessment plan and in annual sewer rentals, have been received with little enthusiasm and with no success. It appears almost impossible to find a municipal official who is willing to advocate a change to the assessment plan and sponsor an unfamiliar and probably unpopular financial program, even though such a program might result in a more equitable distribution of the charges.

Baltimore now makes use of the front-foot assessment method only for paying for the opening of new streets and for the development of highways, although a large portion of such work is financed by general taxation. It has not yet reached the point of looking with favor upon the application

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of similar plans to the extension or development of sanitary facilities. As Mr. Wolman points out, the obstacles to setting up any new plan of financing in an old territory are likely to be insurmountable. The practicability of so doing is somewhat remote. Paying for municipal utilities by general taxation has the political advantage of simplicity and of familiarity. The fact that it may not always be equitable in all directions appears to be an evil of no great import to a sufficiently large population to warrant change.

The matter of determining upon the logical and practicable method for financing sewerage systems* has given the writer considerable concern for a number of years. In the course of studies and investigation of the problem in Baltimore city, considerable information as to the procedure in other cities has been accumulated on the problem. Some of this has been summarized in Table 2. It is included here because the general information contained therein may be of interest to the readers.

There are, of course, many variations in many cities in providing for the construction of sanitary facilities, which might be discussed at great length. For example, real estate developments in the city of Baltimore ordinarily construct at their own expense the sewers in the area they are developing. These are constructed according to the plans and under the supervision of the Baltimore City Sewerage Division. As these sewers are connected to and discharge into the sewerage system of Baltimore city, they become the property of the city at no cost. Under this plan the property purchaser in such a development pays for his part of the sewerage system in the cost price of his property. He pays twice for a part of it, however, through the general taxes on his property. This procedure has been developed as a partial substitute for the front-foot assessment plan in newly developed areas. It has functioned with success, even though the plan does result in some double payment for the same facilities. The real-estate developers favor the method, and it has operated successfully and to the advantage of the city.

In closing, some comment should be made upon the plan in use in some cities, of paying contractors for sewerage system construction in municipal sewer bonds, rather than in actual cash. This procedure is commented upon at this time for it undoubtedly frequently works to the disadvantage of the taxpayer. Our experience shows that, when the contractor is confronted with the necessity of distributing these bonds to bondholders, he is likely to charge more per unit of work, on account of the added risk he assumes in accepting bonds and in looking for a purchaser for such bonds.

WALTER C. MUNROE.† The Anne Arundel County Sanitary Commission was created by Act of the General Assembly of Maryland in the spring of 1922. Before discussing the financial experiences of the Commission, a brief synopsis of the principles upon which the Commission is founded will be given in order that the reader may have a clear understanding of

* "Financing the Baltimore Sewerage System," Ruark and Keefer, *Engineering News-Record*, May 5 1927.

†Chief Engineer, Anne Arundel County Sanitary Commission, Glenburnie, Md.

CITY.	Percentage of cost of construction assessed against abutting property owners.	Percentage of construction paid
1. Baltimore.	No sewers are built by assessing abutting property owners.	Sewers built loan (See Note
2. Buffalo.	100%	Non
3. Boston.	He pays $2.00 per front foot, and assessment is applied to both sides of street.	Remainder city.
4. Chicago.	100%	None
5. Cleveland.	(See Note No. 4.)	(See Note
6. Detroit.	100% of lateral system only.	100% of sewers.
7. Los Angeles.	100% of lateral system only.	100% of sewers.
8. Milwaukee.	$1.25 per front foot.	Remainder city.
9. Minneapolis.	$2.50 per front foot.	Remainder city.
10. Newark.	Average for 15 yrs. 85%.	Average for 15%.
11. New Orleans.	100% for laterals for storm-water drains only.	100% of sani tem and all water system laterals.
12. New York.	100%	None
13. Pittsburgh.	100% if under 15 in. in diameter. Otherwise, pay cost of a sewer 15 in. in diameter.	0% if sewer in diameter or Otherwise pay excess of co sewer 15 in. eter.
14. Philadelphia.	In 1918 he paid $2.50 per front foot. (Since 1920 rate was made $4.00.)	Remainder pa city.
15. San Francisco.	$2.50 per front foot.	Remainder pa city.
16. Seattle.	....	A portion o sewers paid Bond Fund.
17. St. Louis.	100% of lateral system only. Cost of laterals has been about 60% of all sewer costs.	100% of trunk only. Cost sewers has bee 40% of all sew
18. Washington.	$3.00 per front foot, for lateral sewers only.	Remainder of system cost city. City pay of cost of trunk and Federal 26.5%.

NOTE 1. Previous to 1906 some few sewers were built by assess sewers are built by land development corporations, which are designe for the designing and the supervision of the construction of these sewe

NOTE 2. Net debt in 1925, including Boston's share of State Me

NOTE 3. Including Boston's share of State Metropolitan Sewera

NOTE 4. City always pays (a) cost of street intersections. The (c) the deficiency arising from (b).

NOTE. The informati

age of cost of con- n paid by the city.	Time allowed abutting owners to pay assessments.	Basis of apportioning cost to abutters.	Total cost of sewerage system to date, exclusive of maintenance.	Average annual cost of maintenance.	How is cost of maintenance provided?
s built by special loans. e Note No. 1.)	....	....	$59 100 000.	Sewers $375 000 Pumping 89 500 Disposal 114 300 Total $578 800	Tax Levy.
None.	For work under $5 000 assessment becomes a lien at once. Otherwise payment is made in from 5 to 20 annual installments.	Front foot and square foot.	$13 000 000.	$20 000.	General fund.
nder paid by	30 days after completion of work, otherwise, in ten (10) annual installments with interest @ 6% on unpaid balance.	Flat front foot rate.	Not reported.	$968 000.	Tax Levy.
None.	3, 5, 10 years.	Front foot.	$52 000 000.	About $700 000 in 1925.	Appropriated by City Council.
Note No. 4.)	Five annual installments.	Front foot.	Not reported.	About $270 000.	Tax Levy.
of all other	25% upon completion of work and balance in three installments.	Area of land.	About $80 000 000.	About $15 000.	Tax Levy or Bonds.
of all other	10 years.	Front foot and area.	....	$180 840.	Tax Levy.
nder paid by	3 years.	Flat front foot.	No record.	No record.	Tax Levy.
nder paid by	5 annual installments and interest @ 5% on deferred payments.	Flat front foot.	$13 740 000.	About $56 000.	Tax Levy.
e for 15 years. 15%.	First payment 60 days, then 5 annual installments.	Front foot.	Not reported.	$100 000.	Tax Levy.
f sanitary sys- d all of storm- system except	About 10 years.	Front foot.	$32 000 000.	$520 000.	Water rates and Tax Levy.
None.	10 yrs. — If assessment exceeds 3% of Land Value.	Area of land.	$132 532 500.	Not compiled.	Tax Levy.
sewer is 15 in. eter or smaller. ise pays cost in of cost of a 15 in. in diam-	2 years.	Benefit to property.	Not available.	$40 000.	Tax Levy.
nder paid by the	6 months after completion of work, otherwise becomes a lien on property.	Flat front foot.	No record.	$75 000.	Tax Levy.
der paid by the	Total assessment is due when work is completed.	Flat front foot.	$10 000 000.	$144 000.	Tax Levy.
ion of trunk paid by Gen. und.	12 to 22 years, majority 12 years.	Front foot.	Not reported.	Not reported.	Tax Levy.
f trunk sewers Cost of trunk as been about all sewer costs.	From 1 to 10 years, usually from 1 to 5 years.	Area of land.	Not reported.	$125 271.	Tax Levy.
der of lateral cost paid by ity pays 73.5% f trunk sewers ederal Gov.,	⅓ in 30 days and remainder in 2 annual installments.	Flat front foot.	No record.	Average for last 10 years $261 320.	Appropriations by Congress and Tax Levy.

y assessment, by private individuals, and out of the general tax levy. At the present time, a number of lateral sanitary designed by and built under the supervision of the city, and in turn become the property of the city. No charge is made ese sewers.
State Metropolitan Sewerage System's debt.
Sewerage System's maintenance cost. Actual maintenance cost by city of Boston is $518 840.
s. The abutters pay (b) the remainder, provided, the rate does not exceed $4.25 per front foot. Otherwise, the city pays

nformation tabulated for Minneapolis and Pittsburgh is not of recent date.

the subject. The enabling Act was modeled after that of the Washington Suburban Sanitary District, which had come into being a few years prior to this Act and which had functioned most successfully.

There are two points of wide variation in the acts governing this Commission, and those of the Washington Suburban or other neighboring commissions, which may prove of interest to the reader; they are as follows:

1. This Commission until 1927 was limited in the size of the districts incorporated to two square miles each, but could create any number of such districts, within a certain area, at its discretion. 2. All county-owned streets or thoroughfares were automatically transferred to the Sanitary Commission, and all road taxes collectible within any sanitary district were paid over to the Sanitary Commission to be expended for road, sewer or water projects as deemed most necessary.

Three sanitary districts of less than two square miles each were incorporated immediately and the necessary sewer and water projects were begun. Space will not permit discussion of the many interesting phases of an arrangement of three, and, later on, four separate and distinct sanitary districts, where all benefit assessments, general taxes, collections, supplies, labor and what-not had to be kept in separate accounts; and where rivalry, coupled with the human desire to grab the most for the least money, made for keen competition, both political and otherwise.

All improvements since the creation of the District, until June, 1927, were carried out under the above arrangement, but since June 1 certain amendments to the original act have taken effect whereby the various separate districts have been merged into one district, and sub-district divisions have been made, where necessary, in carrying out any particular project.

The question of road ownership will only be touched upon, inasmuch as it has affected the total income of the District. In this connection it should be mentioned that, of the total road tax collected, approximately 40 per cent. has been expended for road purposes, the balance being diverted to sewer and water construction. Many thoroughfares were taken over in addition to those which were transferred through the County Commissioners. After the laying of sewer and water pipes all were reconstructed and surfaced with gravel or other hard material so that their final condition was far superior to the original. Such procedure, while somewhat unusual, has certain advantages in that it permits the correct establishment of surface grades with respect to underground structures, and also eliminates the inevitable controversies and cost settlements which arise over tearing-up and repaving streets. In any event the management of streets under the above method has resulted in far greater improvements throughout the thickly settled areas than would otherwise have been possible. While it is obvious that the above arrangement could not, in all cases, be successfully carried out between different political subdivisions, it has won popular approval in this instance.

In discussing, as thoroughy as possible, in the space available, the financial experiences of the Commission during the past five years, we assume that the three commissioners, in whom the administrative powers are vested, are men of average intelligence and business ability, who may or may not be familiar with the requirements and duties they are about to assume. If the act under which they are to operate has been sensibly drafted, it will be sufficiently flexible to permit the use of forethought and good judgment in arriving at the general tax, front-foot assessments, water rates and other charges from which sufficient revenue must be derived for successful operation.

Without going into details, it should be apparent that the taxpayer must be approached with assessments, taxes and other charges which are readily understood, which are in no manner distorted, complicated or

TABLE 3.
TYPICAL EXAMPLES OF CHARGES.

Class.	Frontage, feet.	FRONT-FOOT ASSESSMENT.		Water Rent.	General Tax.	Total.	SAVING IN	
		Sewer.	Water.				Insurance.	Water Rent.
Subdivision 1st Class.....	57	6.27	9.12	18.00	1.78	35.17	20.10	6.00
1st and 2nd Class	200	17.88	28.00	15.00	0.81	61.69	11.25	9.00
Business.....	50	6.50	9.00	23.85	1.50	40.85	61.20	0.15

camouflaged and which will stand up under fire of the taxpayer or courts of law. While it is utterly impossible to extract money from all manner of persons without comment or protest, it is possible to establish a fair and equitable method of securing funds through special assessments, general tax or otherwise as the law provides in such cases.

In the case of this Commission, bonds have been issued from time to time as required, bearing interest not in excess of five per cent. and maturing thirty years from date of issue. In order to meet the interest and sinking-fund requirements on the bonds, the law provides that front-foot assessments shall be levied against all properties abutting sewer and water pipes and that in addition thereto a general tax can be levied upon all properties within the sanitary district or districts, if necessary.

The law also provides for the classification of properties, for additional subdivision of rates of assessment and other details that may be exercised at will in the best interests of the community. Complete details of assessments and classifications for the current year are shown in Table 3. No figures are given covering assessment on properties abutting sewer or water systems that were purchased and that bear a lower rate.

In arriving at the front-foot assessments every effort has been made to

provide for a fair and equitable distribution of the revenue required. It may be necessary in other communities where a different average of lot widths prevails or where classifications are different, to modify the assessment to suit local conditions to better advantage, but in this instance the rates herein shown seem to fulfill all requirements.

In addition to the front-foot assessment, there is a general tax amounting to five cents per 100 dollars, levied on all properties within the Sanitary District. This tax is really an indirect benefit tax and is in a large measure applicable to the cost of constructing water or sewerage systems or plants of sufficient size to meet future requirements. There is always a considerable area in any sanitary district which is partly or totally undeveloped but which has been fully provided for in the pipe sizes, storage capacity, etc., of the system thus far constructed. It is only fair that the owners of such properties bear a small part of the cost, which should be regulated by local conditions. During the first two years, a general tax amounting to ten cents per 100 dollars was levied against all assessable property, but due to the extension of sewer and water mains, it has been reduced to the present rate of five cents per 100 dollars.

When first levied, the general tax met with considerable protest and opposition, but a thorough explanation of the matter brought the desired results and there has been no litigation nor further difficulties in this direction.

In accounting for operation and maintenance expenses, all overhead, *including engineering, on new construction* was charged directly to the bond issue. Our original act provided that all administrative and operating expenses, including maintenance of sewer and water mains, should be derived from the sale of water. In actual practice it has been found impossible to carry out such a program in this district. There is considerable speculation as to the outcome in other sanitary districts where the same procedure must be followed.

In the event that no further construction work is to take place, it may be possible to disband the construction organization and settle down on a basis of maintenance and operation supported by revenue derived from the sale of water. In the case of this Commission, conditions warranted the retention of the engineering force, not only for the purpose of carrying out contemplated work, but also to complete the permanent records. In order to meet the situation it was necessary to amend the law in such manner as would provide sufficient funds with which to continue the necessary operations. Accordingly it was provided that the Sanitary Commission should submit a budget to the County Commissioners at the beginning of each fiscal year to cover such administrative expense as may be necessary to carry out the work after deducting all other sources of revenue applicable thereto. The funds are derived by the County Commissioners from the road tax collected within the Sanitary District and not from outside sources. This arrangement has proved successful and has won popular approval.

In conclusion, four typical examples are given in Table 4, of assessments, water charges, etc., together with actual figures to illustrate how the consumer has been affected by the recent improvements. In this connection it should be noted that all of the communities prior to being incorporated by this Commission had private water systems, and were charging $24 per year per service, plus amounts varying from $50 to $150 for tap and service connection. In other cases prospective consumers were forced to purchase $100 worth of stock in the water company before connecting with the main. The insurance rates for private homes amounted to 55 cents per 100 dollars and 61 cents per 100 dollars on furniture and fixtures. Since the installation of new mains and appurtenances the insurance premiums have been reduced to 31 and 34 cents, respectively, on the above units. Sewer and water services are installed by this Commission to the

TABLE 4.

Classification.	Front-foot Assessment.		Water Rates per Quarter.
	Sewer.	Water.	
Subdivision,			
First 150 ft...	.11	.16	From 1 to 10 000 gal. 40 cents per 1 000 gal.
Excess.....	.0275	.08	Next 20 000 gal. 30 cents per 1 000 gal.
Business,			
First 150 ft...	.13	.18	In excess of 30 000 gal. 20 cents per 1 000 gal.
Excess.....	.065	.09	Minimum charge $2.50.
Small Acreage,			
First 150 ft...	.11	.16	There is no ready-to-serve or meter-rental charge.
Next 150 ft...	.0275	.08	
All over 300 ft.	.01	.04	
Agricultural,			
First 150 ft...	.11	.16	Where meters are not installed the flat-rate charge is $15 per year on residential and $24 on business classifications.
Next 150 ft...	.01	.01	

property line at $35 per service; the water connection charge includes the cost of meter and setting. With very few exceptions consumers are metered and, where meters are not installed, the flat rate charges shown in Table 4 apply.

Bernard Siems.* In his article Mr. Wolman states that "the theoretically perfect financing procedure starts as a failure, because it is a departure from the familiar, and a change connotes to the citizen a danger."

It is quite true that the practical application of a theoretical procedure is the primary consideration, but in the case of communities, educational methods may be employed to enlighten the citizens as to the more equitable and advanced policies to be put into effect.

A feasible means of financing a project should not be entirely disregarded

*Vice-President and General Manager, North American Water Works Corporation, New York, N. Y.

merely because of the superficial objection of taxpayers. It is an inherent quality of human psychology for an individual to demand the maximum benefit for the minimum cost. Proper educational methods that present to the citizens of a community the actual facts will very often prove an adequate means for offsetting the majority of such difficulties.

Unfortunately, however, the municipality, in most cases, has not at its command the means for carrying out such methods. The opposition encountered may be considerably reduced by public utilities, privately operated, offering the educational methods, which are so imperative to success, in combination with the close personal contact between the operators and the individual consumers. By these means the reasons for the inauguration of such financial policies may be explained. The tremendous progress of privately operated public utilities in the last decade clearly proves the soundness of this system.

Mr. Wolman also refers to the diametrically opposite procedures that may be enforced in two political entities separated only by an imaginary line, popularly described as a "political boundary."

Flagrant inefficiency in both management and operation of small water and sewerage works controlled by municipal officials, is, unfortunately, only too frequently encountered. These same plants, under the efficient operation and standardized policies of management of a large utility, would flourish and, quite obviously, the benefits derived in the latter case would accrue to the consumer. This type of management would also prove the means of eliminating the various differences between two adjoining communities, that so often prove disastrous to the welfare of both parties involved.

When the assessment method of financing is employed by a municipality and the extensions to the water plant are financed by bond issues, a period is reached when the total of the bond flotations exceeds the allowable percentage of the taxable value of the community. Improvements are consequently delayed, and the development of the community is greatly retarded. In the case of privately operated utilities, the assessment method of financing improvements (particularly extensions to the system) has been found unsatisfactory. In fact, I seriously question the advisability of its adoption for the financing of extensions to municipal plants.

When the writer was acting in the capacity of a municipal official, ample apportunity was afforded for the study of an assessment plan, advanced by him, which incorporated the identical ideas covered by Mr. Wolman's paper. After discussing the many disadvantages of the assessment plan and observing the benefits derived by the consumer under the guarantee plan, the writer had become a firm exponent of the guarantee system for the financing of water-main extensions before he severed his connections with the municipal corporation.

The guarantee system is far more feasible for water works. The cost to the consumer is less, as this plan requires the consumer to guarantee for

a certain length of time only that the revenue derived from the extension equals the annual charges properly applicable thereto. The charges applicable to an extension may be determined as follows:

TABLE 5.

TOTAL ANNUAL COST APPLICABLE TO WATER-MAIN EXTENSIONS.*

(Based on an average 400-ft. extension, 6 in. in diameter.)

Total Cost of Extension — 400 ft. × $3.00	$1 200.00
A — Interest on cost of extension 4% × $1 200	48.00
B — Depreciation of extension 2% × $1 200	24.00
C — Maintenance of extension 2 400 in.-ft. × $.004	9.60
D — Proportional Consumption Cost 240 thousand cu. ft. × $.61	146.40
E — Capacity or readiness-to-serve cost chargeable to extension 2 400 in.-ft. × $.02	48.00
F — Consumer fixed-cost chargeable to the extension 20 × $2.00	40.00
Total Annual Cost applicable to the Extension	$316.00
Or, $0.79 per lineal foot	$400.00

In the cases of privately operated water works, where a fair net return on the value of the plant is earned, such a policy would probably not be followed. Ordinary extensions could be financed from the depreciation reserve, if permitted by the Public Service Commission, or from other surplus reserve funds. This procedure would be advisable as the utility is entitled to earn a fair net return on the cost of the extension, thereby resulting in a profitable investment.

Some of the privately operated water works extend water mains into undeveloped territory when 40 per cent. of the prospective revenue, which amount covers the fixed service-costs, equals the interest charges on the investment. For instance, considering a 400-ft. extension supplying twenty consumers the revenue derived amounting to $400 per year, and the cost of the extension totaling $1 000, the yearly interest charges at 6 per cent. equal $60. This amount, capitalized at 40 per cent., equals $150. Deducting the revenue received from fire-hydrant rental of $30 per year, the net income required from consumers along the extension equals $120. This is 12 per cent. of the original cost of the extension.

Caleb Mills Saville, in his article entitled, "Financing Municipal Water Supply Extensions," published in the *Journal of the American Water Works Association* of January, 1924, states that the income from the extension should equal about 25 per cent. to 28 per cent. of the cost of installation. Under any conditions, the consumers should be required to guarantee that the annual revenue will cover the interest charge of 6 per cent., the depreciation charge of 1½ per cent. and the maintenance charge of ½ per cent., or a total of 8 per cent. of the cost of installation of the main.

*It will be noted that the total annual cost applicable to water-main extensions totals $.79 per lineal foot. This amount is approximately 25 per cent. of the cost of installation of $3 per foot. The analysis applies to municipally operated water works and was prepared considering the existing water system and the method of financing improvements to the plant of the Water Department of Baltimore city.

The policy for the financing of water-main extensions should be formulated considering the financial condition of the utility and the layout of the water system. For instance, a utility of sound financial structure with rates that permit the earning of a reasonable return on the investment and with feeder mains traversing undeveloped territory, is in a position to apply a liberal policy for the financing of water-main extensions. In any case, the charges properly applicable to the extension should be borne by the individual consumers along the main and not by the water consumers as a whole.

In some cities with privately operated water works from 7 to 12 per cent. of the original cost of the extension is charged. I am in accord with this view — in fact, this is the principle on which we work with our holdings. Such a plan is in effect in a large percentage of privately operated water utilities; also privately operated sewerage systems.

Regarding general improvements to the water or the sewerage systems in a small community, does it not appear advantageous for everyone concerned to adopt a plan whereby all of the existing or prospective consumers are afforded the opportunity to invest in the project as individuals or as an organized group of citizens, or as an incorporated company? The inauguration of such a policy is particularly advisable for an unincorporated community where it is not possible to obtain adequate security for local, municipal bond flotations. It is beneficial to both the privately operated utility and to the community, as a saving to the company is effected by a lower cost of financing, and the consumer is given the opportunity to secure a very profitable investment. Many of the larger utility companies have encouraged the sale of securities among the consumers, which procedure resulted in greatly enhancing the good will of the companies and stimulated a more direct and personal interest in operation of the utilities by citizens of the communities. Experience has proved that the reputation of the utility for the rendering of efficient public service is far more pronounced where such a plan is in effect than in the case of taxpayers of a municipal corporation.

I believe that, in view of the conditions confronting Mr. Wolman in Maryland relative to the financing of water-main extensions by a municipality, the better system for him to follow in this particular case is the front-foot assessment system. It is merely intended to point out here that the operation of a large group of small plants by a private concern may result in decreased cost of service to the consumer, in view of the more efficient and standardized methods of management, together with the taxes paid to the community.

Caleb Mills Saville.* This paper is another of those valuable and interesting discussions on special-assessment procedure which have been found very helpful in allocating costs of water-plant operations in rate-making studies.

*Manager and Chief Engineer, Board of Water Commissioners, Hartford, Conn.

Attention is called by the author to the opportunity to carry on properly in new developments rather than to make radical changes in established custom.

The scheme as outlined by the author is based on close connections with the municipal budget. Here in the North it is very common practice to put the water-department finances on a separate basis, and I am inclined to think that Mr. Wolman would assent to this if the matter of "expediency" and departure from local custom did not intervene.

In his discussion of front-foot assessment the author mentions financing distribution pipe lines by bond issues running from thirty to fifty years. The speaker is more favorably disposed to shorter-term issue, periods or serial bonds, and, if possible of accomplishment, he is even more inclined to favor a sufficiently high water rate to permit of assessing a large part of the total cost against abutting property without bond issue, the city or the department assuming the remainder and passing it on to the whole body of consumers, through the rate structure. In other words, a pay-as-you-go policy for distribution work. To the speaker there seems no reasonable excuse for continuing the cost of house connection over any term of years, as the owner of property can well afford to include this comparatively small charge in his development expenses. Right here it seems desirable to point out that one of the greatest troubles in water-supply financing as applied to distribution work is the attitude of a large number of land developers in attempting to enhance the value of their property at the expense of public expenditure. It certainly seems logical procedure for property valuations to be advanced at once on the installation of water from the public supply.

I am extremely glad to hear the author express himself so definitely in favor of assessment of property for water-supply improvements. Of course, our friends of the private water companies somewhat criticise this method because it is not open to them as a means for financing, but they have other opportunities that are closed to a municipal plant. The city of Hartford, Conn., has now for five years financed the laying of all of its distribution pipes by assessment, and this method appears to be satisfactory. The charge is based on the average cost of laying 6-in. pipes the previous year. For 1927 this cost, including overhead, was $1.57 per running foot of assessable frontage. Connections are charged to the applicant at the following rates which install an approved pipe from the main to the property line:

Size.	Improved Pavement.	Other Locations.
1-in.	$.75	$.45
1½-in.	.90	.60
2-in.	1.05	.75
4-in.	2.80	2.50
6-in.	3.60	3.30

All through this discussion there seems to be the thought that water-department finances are tied in with the city tax levy. To the speaker

this practice seems not to be a good one, nor in accord with best public utility procedure. However, it would be hard to change in places where it is established. It is very gratifying to mark the note of coöperation and apparent desire to smooth out troublesome questions between the municipal department and the consumer, which seems to pervade the whole of this discussion, and this attitude will bring into use, more quickly than anything else, the changes desired by the municipal organization. For the sake of putting on record one other legal reference to the question, "Has the Property been Benefited?" the following quotation is made from Lewis on "Eminent Domain," Sec. 254: "If the use is open to all, upon equal terms, who are so situated as to be able to enjoy the privilege, it is immaterial how few actually avail themselves of the right. The amount of benefit to be determined from a particular improvement or system of improvements is a consideration which addresses itself to the legislature and not to the court."

ALLEN HAZEN.* How do these water districts select their management, the men that run them?

Mr. WOLMAN. We have in each metropolitan district a different arrangement. The oldest is in the Washington Suburban Sanitary District. In this area there are three commissioners, totally independent of the county commissioners. The district covers parts of two of our counties. One commissioner is appointed from each county upon the recommendation of the State Board of Health and the third is appointed by the Governor.

In the Baltimore County Metropolitan District, after much travail and argument, the county commissioners were selected to function as the district commissioners, although the district covers only part of the county.

The third, the Anne Arundel County Sanitary District, has all three of its commissioners appointed by the county commissioners, with no ratification by either the Governor or the State Board of Health.

The Salisbury district is under the jurisdiction of three commissioners named in the legislative act. The district functions independently of the Mayor and Council.

Mr. HAZEN. Is the Anne Arundel County District co-extensive with the county?

Mr. WOLMAN. It is not and presents another form still. Portions of the county may be organized as sub-districts for water supply or sewerage and they are administered by one commission.

Mr. HAZEN. What is the population of these districts?

Mr. WOLMAN. The Washington Sanitary District now has in the neighborhood of 60 000 inhabitants spread over some twenty communities, some incorporated, some not incorporated; some having had sanitary systems, others with no facilities.

The Baltimore County Metropolitan District is approaching a popula-

*Consulting Engineer, New York, N. Y.

tion of 75 000. The Arundel County area under district control has probably 20 000 inhabitants. The Salisbury systems are available to perhaps 15 000 people.

Mr. HAZEN. Each one has a single source of supply?

Mr. WOLMAN. There again we have a great variation in procedure. The Washington Suburban Sanitary District covers all the thickly populated territory in Maryland around the District of Columbia. It grew up because of the overflow from the District of Columbia into Maryland. The population is primarily residential. The original plan was to take water from Washington. The plan for sewerage was to tie into the Washington sewerage system. The Maryland district waited so long for these facilities that it finally decided to build its own water supply, filtration plant and sewerage system. It now operates three filtration plants, with sources of water in Maryland.

The Baltimore County area takes water from Baltimore city, which results in the several disabilities pointed out in the paper. The water mains are constructed in the Baltimore County area by the Baltimore County District and are operated by Baltimore city by a joint legislative agreement.

In Arundel County there are independent supplies, eventually to be tied up with Baltimore city, because it surrounds the southern end of Baltimore city.

Mr. HAZEN. Are there any water companies in these districts?

Mr. WOLMAN. There are no water companies in these districts, except one in the Baltimore County area. Private water works, originally in these areas, were absorbed by the districts, so as to make public ownership general.

EDWARD WRIGHT.* Is there frontage assessment?

Mr. WOLMAN. There are four classes of assessments in these developments: one, on the strictly residential or subdivision areas; the business territory, with a higher front-foot assessment; a small acreage assessment; and agricultural land, which has assessment on a sliding scale. In one or two instances the agricultural land is not assessed until water is used by it.

These classifications, and the whole question of the class of property, have occasioned most of the trouble in administration. Every man feels that his property is wrongly classified, naturally, if it goes into too high a class of payment. This has caused some court proceedings, in which the districts have won in practically every case. The courts have decided that it is entirely within the discretion of the Metropolitan District to determine for itself what class you belong in and what charge you shall pay. In other words, they have definitely and flatly said that you do not have to establish a distinct mathematical relationship between benefit and assessment. This helps a lot, of course, because it is almost impossible to determine assessments with complete mathematical accuracy.

*Massachusetts State Department of Health, Boston, Mass.

Mr. SAVILLE. It is not quite clear to me what the relationship is between water rates that must be charged as tax service in the State, or in these districts. Some of the three charges that he has go to the consumer directly, and others, apparently, come from the general tax. I would like to ask where the income goes, and how it is mixed up with the general tax, and how they get their money back for water-works construction work?

Mr. WOLMAN. The funds for water-works construction, which I lumped as the total fixed charges, come out of only two sources,— the front-foot assessment and the general tax. The division between those two sources is determined by a reasonable distribution that would result in an assessment charge on the property holder somewhat equivalent to the cost of supplying him with a 6- or 8-in. water main or an 8-in. sewer. That is all that he pays for.

In the first column of Table 1, the front-foot charges in most cases, or the total front-foot assessment annually, is between 26 and 30 cents for water and sewer, or, roughly, between 12 and 15 cents per front-foot per year for each. That represents an average cost of about two dollars per front-foot, which in these districts would represent about the cost of the 6- or 8-in. water main or sewer. That is all that comes out of the assessment. The cost of all filtration plants, of all mains in excess of 6-in. or 8-in. in size, the cost of pumping systems,— all come out of general taxation. That gives you a constructed system. From that point on, the operating charges for either water or sewer and all maintenance charges come out of the water-service charge, or water-consumption charge, and jointly with that the sewer rental.

Mr. SAVILLE. If I remember, in the scheme that you and Mr. Morse, I think, proposed, the agricultural land could be redistricted after a certain time. Now, who carries the cost of the pipes in front of that property until such time as the land itself will pay it?

Mr. WOLMAN. Until it becomes assessable?

Mr. SAVILLE. Yes.

Mr. WOLMAN. That same land, of course, carries its proportion of the taxation. It is not exempt from general taxes, which you will note rarely exceed 5 cents on the $100. That has caused the least contest, because it is so small. The cost of water or sewer lines that pass this agricultural property is borne in the general taxation. When that agricultural land is subdivided it immediately comes under the new classification and begins to pay its proportionate front-foot assessment.

Mr. SAVILLE. And when does the land come out of the agricultural class?

Mr. WOLMAN. The minute there is any evidence to the commissioners of its use for other than agricultural purposes, either through the recording of plats for subdivision or the actual use of the land for subdivision purposes.

Mr. SAVILLE. Of course, that land becomes immediately more valuable the minute the water pipe is placed in front of it.

Mr. WOLMAN. That is true. The political inexpediency of trying to prove that to 10 000 farmers is, however, just as obvious. I do not mind saying very frankly that that is a concession to the rural voters in order to avoid swamping the entire project. I emphasized in the paper the varying psychologies and the varying political procedures necessary in each of these programs to assure success. They are to me the most interesting part of the process.

These extra-engineering difficulties represent to my mind the principal difficulty in getting any of these systems in. It is the difficulty on which we concentrate most, because we find the engineering design, the actual construction and the ultimate financing will take care of themselves quite nicely. The engineers will watch the design and the construction, and the fiscal agents will finally collect the funds, but the initiation and the affirmation of a project are different matters. That is, we set up the most excellent theoretical plan in as perfect a syllogism as we can get, and then we begin to distort that syllogism until finally some plan is reached which is generally acceptable. In the distortion we try to preserve the fundamentals essential to successful functioning of the district, when created.

M. N. BAKER.* The Association is fortunate in having stated to it the principles outlined in this paper, with an explanation of their practical application. Throughout the history of water works in the country there has been little but haphazard method or mere chance in distributing the cost of water-works construction and operation.

This scheme, as explained here, has been utilized in Maryland chiefly for water and sewerage districts, but the fundamental principles would apply, I think the author would have us understand, to water-works financing generally.

Whenever the matter of frontage assessments, or assessments for benefits, is brought up, I like to go back to that very excellent exposition of the subject, so far as sewerage is concerned — and it really applies to assessments for benefits in general — to that report made over thirty years ago by F. Herbert Snow, when he was city engineer of Brockton, in which he evolved a plan which was put in practice for financing the sewerage system, including the pumping plant, force main and treatment works. Subsequently that plan was extended to other municipalities in Massachusetts and Rhode Island, as described in a series of papers presented before the Boston Society of Engineers, and printed in the *Journal of the Association of Engineering Societies*. Under the Brockton plan the taxpayers as a whole met that part of the cost of the sewerage system that benefited the community as a whole, the individual owners paid their special benefit by a special assessment, and users of the system paid an annual charge. The plan was excellently outlined by Mr. Snow in his report. That was

*Associate Editor, *Engineering News-Record*, New York, N. Y.

long ago, and I believe Mr. Wolman thinks that this Maryland scheme is a considerable improvement upon the Brockton plan.

Just one word as to the application of what is supposed to be the principle of assessment for benefits. It is coming up all the time throughout the country. So far as water works are concerned, some mere rule-of-thumb method is generally used, like a pro rata front-foot basis, without regard to actual benefits; and in the case of many other public improvements the same is true.

WILLIAM W. BRUSH.* Mr. Wolman has brought to the water-works fraternity a very interesting presentation of a plan of logical allocation of costs of water and sewerage facilities for a community, the rather general lack of uniformity in allocating such costs, and the range of charges in various communities in Maryland for the same service. The writer is in general agreement with Mr. Wolman on the soundness of the principles of financing recommended by the Maryland State Department of Health, but is in doubt as to the wisdom, and even fairness, of applying such principles in a community that has operated its water works for many years under a different financial system.

The city of New York is a community where a certain plan of water charges has been followed for about three-quarters of a century. If the present plan were to be changed and the plan recommended by the Maryland State Department of Health were used as a basis for a new plan, there would be widespread discussion, and probably general dissatisfaction with the new plan. The writer believes that a city administration may properly ask itself the following question:

"Is a radical change in the existing system of water rates desirable when the present system is generally satisfactory to the consumers, even if the present system is not altogether an equitable one in allocating to the various classes of consumers the cost of furnishing the water supply?"

If the answer to this question is that there would be general criticism of such a change, the writer believes that the change should not be undertaken. If the water supply system is not self-supporting, and a change in the rate structure is essential to afford additional revenue, then it would appear that the changes made should be along sound financial lines, minimizing as much as possible the change from the existing rate structure.

The charge for water is so small, as pointed out by Mr. Wolman, that it is negligible as affecting the annual living cost of the individual, and on the whole no serious injustice is done if an existing system of apportioning water costs is followed, rather than changing to a different, and what is usually a more elaborate and complicated one. Thus in New York the extension of water mains is paid for by the sale of water bonds, and the interest and sinking-fund charges are met by direct taxation, and the water revenues paid into the general fund. This method is a very simple, indirect

*Chief Engineer, Bureau of Water Supply, New York, N. Y.

payment plan, with the cost spread over many years, and no one knows what percentage of the cost of the main the property benefited ultimately bears. With 3 600 miles of mains laid under this system it is difficult to say if a change to the front-foot assessment plan would now more equitably spread such cost, as the property assessed on the front-foot basis would for many years to come be paying also on its share of the bonds issued for mains laid under the present plan. One should not forget that the taxpayers and rent-payers are the stockholders in the municipal company, and the city officials who are the directors of the company are reasonably called upon to please the majority of such stockholders. If this is not done the directors are soon changed.

The writer would advocate using the plan followed by the Maryland State Department of Health as a general guide when studying changes in a long-established water-rate system, but would not advocate changes in existing systems simply for the purpose of making them more logical if thereby they would not satisfy the majority of the water taxpayers.

PROCEEDINGS.

November Meeting.

Superintendents' Day.

City Club, Boston, Mass.
Wednesday, November 9, 1927.

The Vice-President, Arthur D. Weston, in the chair.

The Secretary announced that at the meeting of the Executive Committee on November 9, 1927, the following were elected members of the Association:

George A. Walker, Lincoln Street, East Braintree, Mass.
Thomas Everett Sears, Braintree, Mass.
John H. Robinson, Box 301, Nantucket, Mass.
James J. Ducey, Framingham, Mass.
George A. Chamberlain, Winslow, Maine.
Richard Robertson Bradbury, Hardwick, Mass.
Preston Meldram Putnam, Enfield, Mass.

The subject of Services — Kinds of Pipe, Coatings, Laying, Cost Keeping, Renewing, Repairing, etc. — was discussed. The discussion was opened by David A. Heffernan, of Milton, Mass., and the following members participated in the discussion: D. A. Heffernan, George C. Brehm, Charles W. Sherman, George F. Merrill, J. G. Lufkin, B. W. Vaughan, Samuel A. Agnew, Roger W. Esty, H. V. Macksey, Henry T. Gidley, Joseph A. Hoy, Albert W. Moore, F. M. Cole, John S. Caldwell, W. Guy Classon, Howard M. King, Dwight Porter.

The subject of Testing and Repairing of Water Meters was discussed. The discussion was opened by Mr. F. M. Cole, Brockton, Mass., and the following members participated in the discussion: F. M. Cole, Albert W. Moore, George F. Merrill, A. R. Hathaway, Henry T. Gidley, Samuel A. Agnew and J. G. Lufkin.

(*Adjourned.*)

FRANK A. MAZZUR — A Memoir.

(Died February 4, 1927.)

Frank A. Mazzur was born February 5, 1871, at Jersey City, N. J.,— the child of Leon Amedee and Hannah Oldfield Mazzur.

Having completed his education, he entered the employ of the Wheeler Condenser and Engineering Company in 1894, beginning in the foundry and thence working up through the machine shop, drafting-room, and engineering department. In 1897 he was sent abroad to supervise plant erections in England. Returning to this country he joined the sales force of the New York office.

In 1907, Mr. Mazzur came to New England and started in business under the name of F. A. Mazzur Company, representing the Wheeler Condenser and Engineering Company and other manufacturing interests, and also contracting for the installation of various water-works and power equipment, in which line of work he continued until his untimely death.

On June 23, 1897, Mr. Mazzur married Mattie Cooper Pearson who, with three sons and a daughter, survives him.

He was a member of the Engineers Club, Brae Burn Country Club, American Society of Mechanical Engineers, and of the New England Water Works Association.

The preceding brief statement all too baldly outlines the business activities of a man who earned for himself a most unusual reputation for fair dealing, engineering ability, and for a constant insistence on the highest standard of craftsmanship in his work. With the enthusiasm of an artist he found joy in every job, and an award to him of a piece of work guaranteed fulfillment not only to the letter, but to more than the spirit of the contract.

To those members of the New England Water Works Association who were fortunate enough to have had business dealings with him, the passing of Frank Mazzur is a very definite loss.

F. A. Barbour.

August 1, 1927.

BOOK REVIEW.

BOILER FEED-WATER PURIFICATION. By Sheppard T. Powell. New York. McGraw-Hill Book Co., 1927. 363 pp., 6 x 9, 158 illustrations. $4.00 net.

Standards of quality for waters used in industry have been rising as certainly as have those for waters supplying domestic needs. The technical literature of recent years contains numberless papers devoted to the purification and economic features of boiler water supplies. It is timely to have this scattered information condensed and brought within the covers of a book by an author who has had long experience in this particular field.

The treatment of the subject pursues a logical development: Beginning with the impurities of natural waters, successive chapters treat of sedimentation, coagulation and filtration, then of hot and cold methods of softening by chemical treatment and softening by zeolites; of evaporators, deaëration, deconcentrators and the use of boiler compounds. Finally, there is treatment of such effects of boiler operation as priming and foaming, corrosion and embrittlement of metal; a chapter on feed-water heaters and one on methods of water analysis. There are twenty-two pages of appendix containing conversion tables, surface and ground water temperatures at different places in the United States, specifications for chemical reagents, examples of blank forms for operation data and the method for a mechanical analysis of sand.

The index is fairly complete, but the table of contents is merely a list of chapter headings. It would serve a better purpose if it contained a synopsis of the subject-matter of each chapter.

The author states that he has written the book as a guide to the designing engineer and as an aid to the operating engineer; endeavoring in his task to simplify exposition of the subject. As a whole the book is easily read and understood, due to wise arrangement of material and good execution of the typographical art. Nevertheless, it is the reviewer's opinion that a subject that is so bound up with chemical phenomena as is feed-water purification could be made more intelligible by a fuller explanation of the chemical aspects of certain topics that are discussed in the book. Those for whom the book is written have some little understanding of chemistry and physics; and if they can assimilate the theory of corrosion, the significance of hydrogen ion concentration and the theory of sedimentation they should be able to follow an explanation of simple chemical reactions, like those the author presents to describe the action of lime and soda in softening water. Such reactions would add greatly to an appreciation, for instance, of the alum reaction and its effect upon hardness constituents; of the chemical behavior of sodium aluminate, the use of which is discussed at length, and of the action of barium salts. The author's use of graphic illustrations to depict chemical changes seems rather futile.

The best chapters in the book are those that confine themselves to processes directly concerned with the treatment and operation of boilers. The more modern procedures are fully described, and earlier and less common practices are not neglected. One commendable feature of the discussions is a summary of the merits and demerits of particular processes or practices. Many cost data are presented. Illustrations are numerous, both photographs and drawings being used. Some of the latter are so reduced in size as to make lettering difficult to read, and in some cases a simplified line drawing would have served better the purpose than a complicated drawing showing detailed features — at least for the student and for those not well-posted on the subject.

One of the longest chapters in the book is that dealing with evaporators. The use

of evaporators represents one of the latest developments in boiler practice. The principle of their operation, their efficiency, and the details of numerous types are given careful consideration.

Developments of the past few years in the degasification of feed water are fully discussed in the chapter entitled "Deaëration of Feed Water." Drawings and descriptions point out the features of different types of deaërators. The fundamental laws governing the solution of gases are presented. This topic would benefit by elaboration. The methods of operating deconcentrators and the conduct of the continuous and intermittent blow-down are subjects of another interesting chapter.

Every designing and operating engineer should read the chapter entitled "Boiler Compounds." It deals effectively with the misconceptions, credulity, and even fraud, that surround the practice of uncontrolled internal treatment of boilers. There is a good discussion of the merits of internal and external treatment.

Corrosion and embrittlement are in the nature of effects of boiler operation. The limits of this volume preclude an elaborate treatment of these subjects, but the author has done well in the space allotted to them.

The material in the chapter, "Standard Methods of Water Analysis," is largely what one might expect to find in an appendix. The engineer is not greatly interested in laboratory procedures and the analyst has other sources of information. Space could have been saved by making this a short chapter on the advantages and needs of chemical control of purification processes, the kind of tests necessary, the information they provide, the proper persons to make tests, and references to the literature on laboratory matters.

The question of the treatment to be accorded such subjects as "Coagulation" and "Filtration," in a book of this character, is debatable. They are too large for comprehensive discussion; on the other hand it is dangerous to define their limitations without adequate discussion. The author has limited "Factors Influencing Coagulation" to one page, and "The Theory of Filtration" to one paragraph. The opinion of the reviewer is that these chapters would have been improved for the purposes of this volume by omission of some theoretical and controversial matters, limiting them to a description of ways and means.

One of the outstanding features of the book is the excellent bibliography accompanying each chapter. It is to be regretted that the references were not either chronologically or alphabetically arranged.

"Boiler Feed-Water Purification" is an important addition to the literature of the field it covers. It has much of value not only for designers and operators of plants, but for students who are interested in water-purification problems.

MELVILLE C. WHIPPLE.

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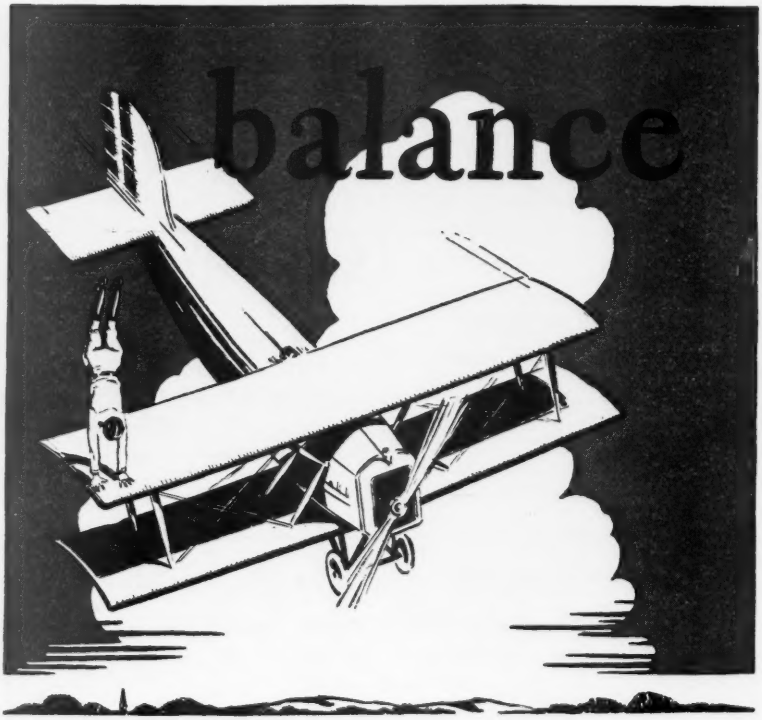

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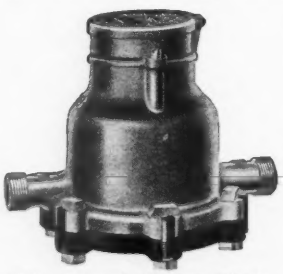

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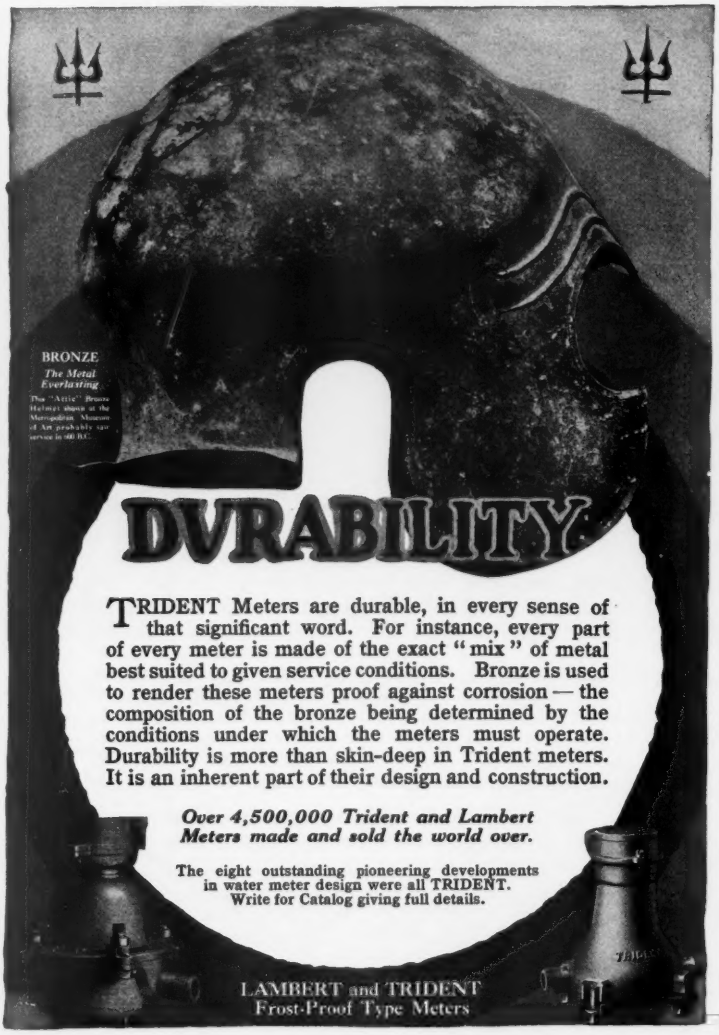


TRIDENT Meters are durable, in every sense of that significant word. For instance, every part of every meter is made of the exact "mix" of metal best suited to given service conditions. Bronze is used to render these meters proof against corrosion — the composition of the bronze being determined by the conditions under which the meters must operate. Durability is more than skin-deep in Trident meters. It is an inherent part of their design and construction.

Over 4,500,000 Trident and Lambert Meters made and sold the world over.

The eight outstanding pioneering developments in water meter design were all TRIDENT. Write for Catalog giving full details.

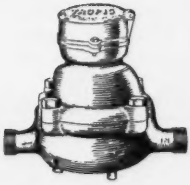
LAMBERT and TRIDENT
Frost-Proof Type Meters

NEPTUNE METER COMPANY
THOMSON METER CORPORATION
50 EAST 42ND STREET, NEW YORK CITY
FACTORY, LONG ISLAND CITY, N.Y.
PIONEERS IN METER PROGRESS

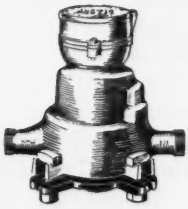
Our Research Laboratory is an important factor in making Better Meters!

AGAIN the initiative in manufacturing better water meters has been taken by the Pittsburgh Equitable Meter Company. Thousands of dollars have been invested in testing equipment and laboratories.

The entire department is at your disposal. Questions in connection with corrosion, water analysis, or electrolysis will be answered gladly and we will be pleased to assist you in working out any difficulties that may give you trouble.



TROPIC



ARCTIC

Pittsburgh Equitable Meter Co.

Pittsburgh Pa.

Branch Offices: New York, N. Y.; Chicago, Ill.; Dallas, Texas; Los Angeles, Cal.; Tulsa, Okla.; Seattle, Wash.; Columbia, S.C.; Salt Lake City, Utah; Kansas City, Mo.

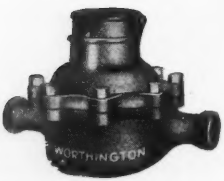
WORTHINGTON

Worthington Water Meters

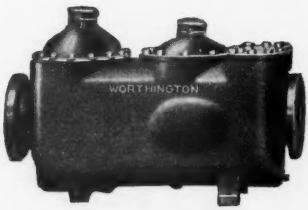
There is a Worthington Water Meter for every requirement from the measuring of small-customer flows to the measuring of flows of 10,000,000 gallons per 24 hours.

Stocks of meters are carried in our branch houses in all parts of the country as well as at our Worthington Works to insure prompt service.

Also manufacturers of hot-water meters for boiler-feed lines; meters for hot oil and meters for cold oil.



Worthington Disk-type Meter for cold water. Furnished with open train or enclosed oil train. Smaller sizes can be fitted with frost protection.



Worthington Compound Meter for cold water.

Worthington Turbine Meter for cold water.

Worthington Products

METERS

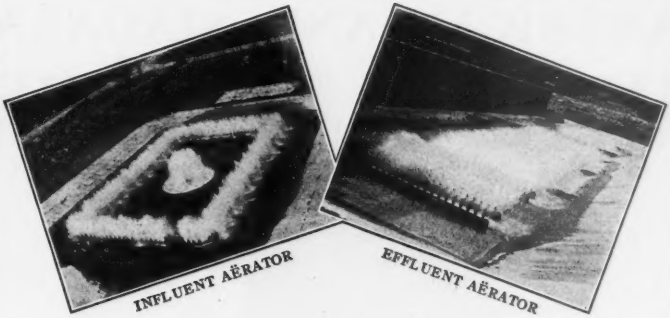
Disk, turbine velocity and compound. Also hot-water meters and oil meters

PUMPS
COMPRESSORS
CONDENSERS *and*
AUXILIARIES
OIL *and* GAS ENGINES
FEED-WATER HEATERS

Literature on Request.

7137-3

WORTHINGTON PUMP AND MACHINERY CORPORATION
115 BROADWAY, NEW YORK CITY BRANCH OFFICES IN 24 CITIES



Views at new Providence Water Works Scituate, R. I.

At Providence

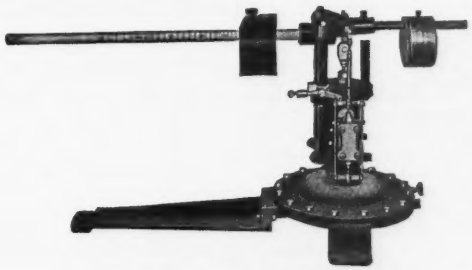
Hazen & Whipple Consulting Engineers, New York, N. Y.

the expenditure of twenty million of dollars and eight years of construction have resulted in providing the city of Providence with an abundant supply of pure clear water.

The Filter Effluent Aërators, a novel idea devised by the Consulting Engineers and developed by Builders Iron Foundry, is of particular interest. The head of water on the filter is used to produce secondary aëration. Constant flow through the filters is maintained by special Venturi-controlled mushroom valves which open gradually as the loss of head increases.

Special Venturi Meters measure the total water entering and leaving the plant; Builders Loss of Head and Rate of Flow Gages guide the operation of the filters.

Write for descriptive bulletins.



CONTROLLER PILOT VALVE UNIT

BUILDERS IRON FOUNDRY

"Builders of the Venturi for 36 Years"

Providence VENTURI "VENTURI" Registered **Rhode Island**

AMERICAN AND NIAGARA WATER METERS

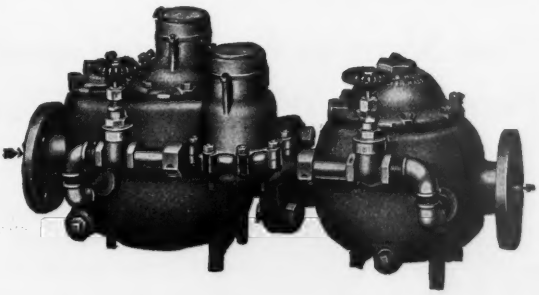
American and Niagara meters are made in solid casing types and frost bottom types. The illustration above shows a 5/8" x 3/4" meter of the frost bottom type. Those meters having bronze outside casings are known as Americans and those having galvanized cast-iron outside casings are Niagaras. The works in all the different casings are of one best model and interchangeable. The registers may be either round reading or straight reading and may indicate cubic feet, U. S. gallons, imperial gallons or litres. All Niagara and American meters are tested and adjusted according to the requirements of the Standard Specifications for water meters adopted by the New England Water Works Association and the American Water Works Association.

Write for large catalog and prices.

BUFFALO METER CO.

ESTABLISHED 1892

2896 Main Street **BUFFALO, N. Y.**



The New Nilo

The new improved **Nilo Compound Meter** now comes equipped with a bronze body. This is a valuable addition to meter service for it eliminates the danger of corrosion and filling up due to the collecting of corrosive matter. Bronze being stronger than iron the gross weight of the meter is less, making it easier to transport, handle and install.

It also has two gate valves which allow the removal of the by-pass meter for cleaning or repairing without shutting off the line.

The controlling valve mechanism of the new **Nilo Compound Meter** is self contained and easily detached from the main body casings.

These three improvements make the **Nilo,** a long standing favorite, the unrivaled leader in its field.

An old-line New England Product
that has kept abreast of the times.

UNION WATER METER CO.
Incorporated 1868
WORCESTER, MASSACHUSETTS

Is Your Pressure Low?
Are You Short on Pumping Capacity?
Do You Know Where Your Water Goes?

OUR Engineering Department will tell you how to determine your water distribution, how to find out whether or not new mains are required, etc. We can supply you with the means for: —

1. Checking up pump performance and determining slippage due to leaky plungers, defective valves, short stroking or other causes,
2. Measuring delivery of centrifugal pumps and figuring whether or not the station is up to efficiency,
3. Distributing proportionately the cost of water supplied to several districts,
4. Checking up the performance of filter beds,
5. Detecting waste or pipe leakage,
6. Recording daily amounts of sewage handled and planning future extensions, etc., etc.

THE SIMPLEX METER

VENTURI, PITOT TUBE OR ORIFICE TYPES

THE importance of exact measurements by means of a Simplex Meter cannot be over emphasized. Mr. Jeffries, Chairman of the West Chester, Pa. Water Works Committee, was able, by checking the performance of his pumping engine with a Simplex Meter, to discover that due to the imperfection and wear in the valves the slippage amounted to 300,000 gallons of water per day. This represented a daily loss of $30.00, or in other words a daily saving of $30.00, or $900.00 per month, when the valves were put in order. The Simplex Meter thus paid for itself in a month's time.

Frequent repeat orders from satisfied customers who formerly used other meters are the best evidence of merit of the Simplex Meter.

We have had many years' experience in solving water flow problems involving all sorts of conditions, and we are at all times prepared to submit general layouts involving cost and capacity, and to make explicit and complete recommendations. Write for Bulletin N26.

SIMPLEX VALVE AND METER COMPANY

Manufacturers of Meters for Water, Sewage, and Other Liquids, Rate Controllers, Automatic Air Valves, Regulating Valves, and Hydraulic Apparatus of Special Design.

6757 UPLAND STREET PHILADELPHIA, PA.

"WATCH DOG" WATER METERS

ACCURATE *DURABLE*

DISC, CURRENT AND COMPOUND TYPES

Inquiries Solicited

GAMON METER COMPANY

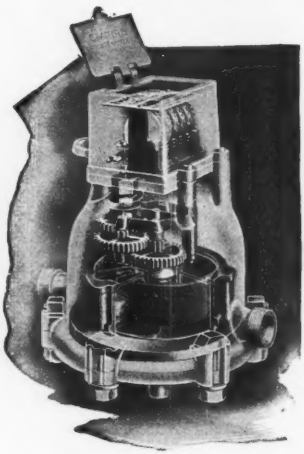
NEWARK **NEW JERSEY**

METERS

Water Departments wishing to make the most out of their supply, to earn the highest possible revenue, and to satisfy their customers, are invited to investigate

The EMPIRE

OSCILLATING PISTON METER



Sizes from 5/8" to 6"

Accuracy, lasting qualities, and economy of upkeep are the three essentials of satisfactory meters. The EMPIRE offers some remarkable records on these three points. Ask us.

Fully descriptive EMPIRE circular gladly sent on request.

NATIONAL METER COMPANY

299 Broadway, New York

Chicago **Cincinnati** **Boston**
Atlanta **San Francisco** **Los Angeles**

FOR THE BIG JOBS!

It is not at all surprising that the Badger Meter with oil-enclosed gear train out-lasts ordinary meters. Particularly where electrolytic or alkaline action is especially severe. Corrosion cannot attack the working parts.

The entire intermediate gear train of the Badger is enclosed in a separate, oil-tight compartment filled with a special non-congealing graphite oil.

The gears are constantly and thoroughly lubricated — protected!

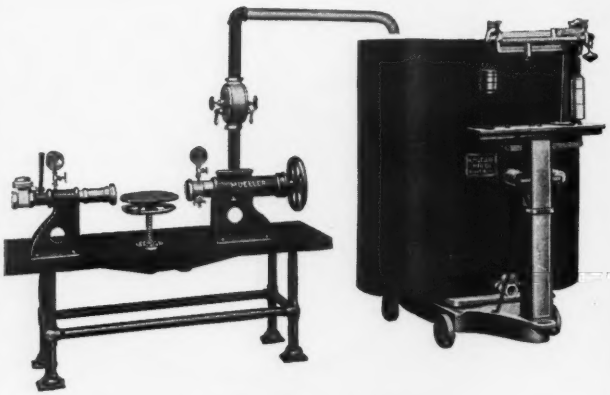
Think of what this means in the life of your meters — in accurate registration — in revenue. Let the Badger prove itself on your lines. Write for detailed information.

Badger Meter Manufacturing Co.
Milwaukee, Wis.

Branch Offices:

CHICAGO, ILL. 111 W. Washington St.
KANSAS CITY, MO. 414 Interstate Bldg.
NEW YORK CITY 52 Vanderbilt Ave.
SEATTLE, WASH. Atlantic Street Terminal, Pier A.
CINCINNATI, OHIO Southern Ohio Bank Bldg.
LOS ANGELES, CAL. 530 A. G. Bartlett Bldg.

BADGER Water METERS



Are Your Meters
Telling the Truth?

Include a Meter Tester in Next Year's Appropriation and End Costly Losses on Those Under-registering Meters.

For the sake of protecting your city or water works against losses on under-registering meters, be sure to include a MUELLER meter tester in your 1928 appropriations. A number of meters, under-registering, will lose more honestly earned revenue over a few months' period, than a MUELLER meter tester would cost. And, according to statistics, meters are much more apt to under-register than to over-register.

It will be to the interests of your city or water works then to be sure to include a meter tester in next year's appropriation. But be sure that the tester which you buy is made by MUELLER of Decatur. The name of MUELLER is already a recommendation to your engineers. And the size and appearance of the MUELLER Meter Tester will inspire the confidence of those who watch the actual testing of the meters.

A MUELLER Meter Tester is simple of operation. It is strongly made; the table is cast iron with wrought-iron legs, and cast-iron head blocks. This tester is made to test meters from ⅝ to 2 inches, and with special equipment, will make tests on 12-inch meters.

Plan now to purchase one for next year — and for years to come.

It will give a lifetime of service, and its cost will be absorbed in the savings you make on under-registering meters.

Write for catalog giving full and detailed description of the MUELLER Meter Testing Machine.

MUELLER CO. (*Established 1857*) **Decatur, Illinois**

Branches: New York, Dallas, San Francisco, Los Angeles
Canadian Factory: MUELLER, Limited, Sarnia

MUELLER

398

ATTENTION
WATER WORKS
OF NEW ENGLAND

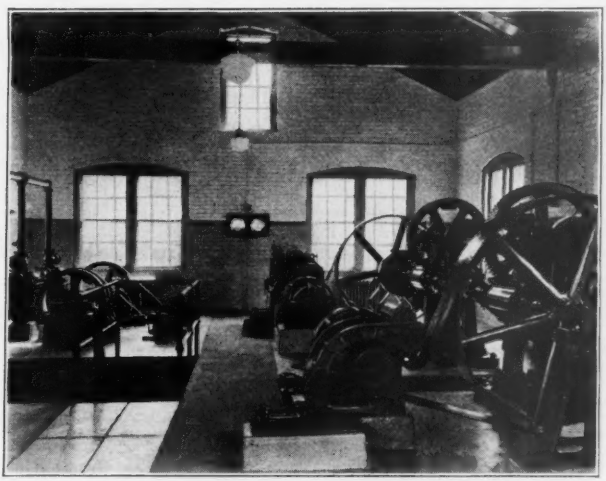
A few reasons why we solicit your inquiries on Water-Works Pumping Equipment:

First. — We make a specialty of furnishing Complete Water-Works Pumping Units of all types.

Second. — Total responsibility of installation is assumed by us.

Third. — We relieve the purchaser of every detail and turn the complete unit over to him under actual operation and with guarantee.

Fourth. — Every unit installed to date has exceeded its guarantee and has been completely accepted.



Remodeled Pumping Station at Bridgewater, Mass., completely installed by F. A. Mazzur Co., Inc. Barbour & Dixon, Eng'r's.

F. A. Mazzur Co., Inc.

141 MILK STREET, BOSTON

STARKWEATHER & BROADHURST, Inc.

79 MILK STREET, BOSTON

CONTRACTORS

for

COMPLETE PUMPING PLANTS

Water or Sewage

"One Contract and Responsibility"

with

"Service Before Profit"

HORIZONTAL AND VERTICAL DESIGNS
MOTOR, STEAM TURBINE OR
DIESEL OIL ENGINE DRIVES
MOTOR AND GASOLINE ENGINE COMBINATIONS

Some Recent New England Installations

Town of Framingham.
Four Motor Units.

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Three Motor Units.

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Eight Motor Units.

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One Motor Unit.

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One Turbine Unit.

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Five Motor Units.

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Three Motor Units.

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One Motor Unit.

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HAYES PUMP AND MACHINERY CO.

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Pumping Plant Contractors

CENTRIFUGAL, POWER, STEAM PUMPS

STEAM TURBINES
WATER WHEELS

ELECTRIC MOTORS
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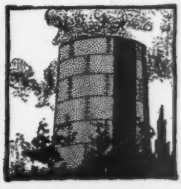
RAY ENGINEERING COMPANY
136 FEDERAL STREET
Boston, Mass.

Power Plant Equipment
Steam and Heating Specialties

For new pumping equipment guaranteed by people who will make good, phone, wire or write the above.
Sales Agents for UNION STEAM PUMP CO.



Standpipes
Water Tanks
Gas Holders
and all other metal surfaces need the protection of
DIXON'S
Silica-Graphite
PAINT
BOOKLET NO. 67-B
JOSEPH DIXON CRUCIBLE CO. Jersey City, N. J.

WE announce our appointment as Sales Representatives of DAYTON-DOWD COMPANY, of Quincy, Ill., Manufacturers of Centrifugal Pumping Machinery. After exhaustive investigation, we present this line of equipment to the Trade in New England as being of the highest grade and thoroughly modern in design and manufacture.

We are prepared to furnish DAYTON-DOWD pumps in all sizes and for all classes of service, in steam, motor, gasoline and belt drive types, and solicit your inquiries, assuring you of our best efforts in your sales and service requirements, and of our appreciation of your continued confidence and patronage.

POWER EQUIPMENT CO.

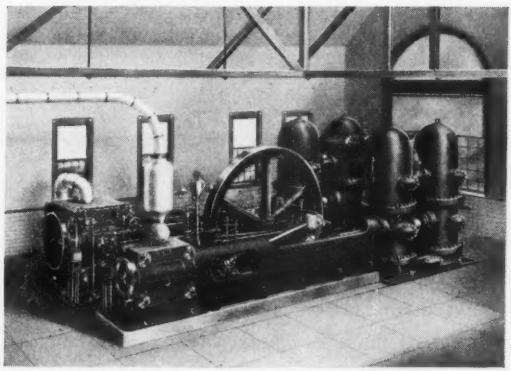
131 State Street, **Boston, Mass.**

MURRAY IRON WORKS CO.

(INCORPORATED 1870)

BURLINGTON, IOWA, U. S. A.

Builders of High Duty Pumping Engines



Murray High Duty Crank and Fly Wheel Pumping Engine, Opposed Type

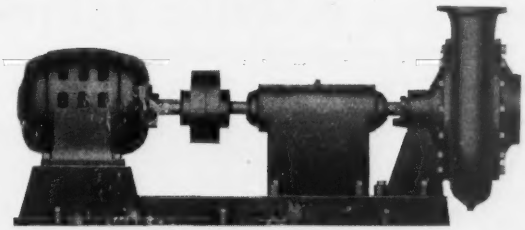
Engineers, Iron Founders, Boiler Makers

Corliss and Una-Flow Engines

Water-Tube, Fire-Tube and Internal-Furnace Boilers

Builders of Complete Power Plants

PLEASE SEND US YOUR SPECIFICATIONS AND CALLS FOR BIDS



Fairbanks-Morse Horizontal Trash Pump direct-connected to Fairbanks-Morse Ball-Bearing Motor

Now a great advance in sewage pumping

For the first time a pump has been designed that will handle fluids containing the fibrous and stringy matter found in sewage — without clogging, without preliminary screening, and without the excessive power consumption that characterizes the less satisfactory open impeller type of pump.

The secret of this pump's success lies in the design of the simple two-blade impeller. The blades of the impeller have well-rounded entering ends and are well filleted with the shrouds or sides. Thus a rag or other trash does not find sharp projections on which to catch and cause clogging. Since the impeller is the enclosed type, foreign matter, in passing through, does not come into contact with stationary side plates, but is promptly discharged through one of the large ports into the pump case. In this way power is conserved and efficiency increased.

This pump was designed by Mr. A. B. Wood who has been serving the city of New Orleans and other municipalities in the capacity of consulting engineer. It was originated by Mr. Wood to cope with the very unusual sewage problems found in New Orleans and met with immediate success.

Fairbanks-Morse Trash Pumps are made in two types, horizontal and vertical. They are ruggedly built to cope with severe service and at the same time they possess such refinements as ball bearings, smoothed fluid passages, and other marks of quality construction.

Ask for bulletins giving complete details.

FAIRBANKS, MORSE & CO., Chicago

28 branches in principal cities at your service.

FAIRBANKS-MORSE

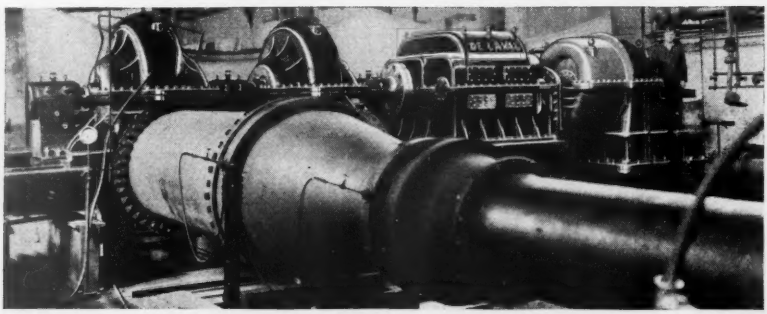
PUMPS · DIESEL ENGINES · MOTORS

DE LAVAL

CENTRIFUGAL PUMPING EQUIPMENT

is the accepted standard for

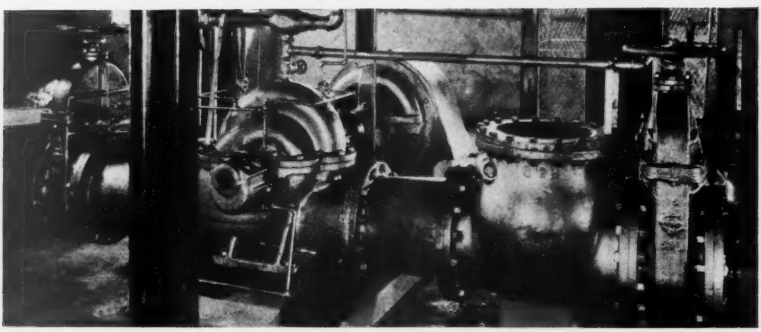
MUNICIPAL WATER WORKS



WESTERN AVENUE PUMPING STATION, CHICAGO.

The largest Municipal steam turbine driven centrifugal pumping unit in the world delivering 75 million gallons per day against 150 feet head.
City of Chicago has fourteen large DE LAVAL pumping units.

TYPICAL NEW ENGLAND INSTALLATION



MILLVALE STATION, HAVERHILL, MASS.

New 7 million DE LAVAL motor-driven pump including the furnishing and erection of transformers and switchboard equipment. On test after installation this pump delivered water at rate of 7,800,000 gallons per day. Another DE LAVAL unit is on order for Kenoza Station, Haverhill.

Recent DE LAVAL municipal water works contracts include New England installations at Canton, Mass., and Millis, Mass.

Ask for De Laval Publication.

TURBINE EQUIPMENT CO. *of* NEW ENGLAND

CHAMBER OF COMMERCE BUILDING

80 Federal St., Boston

NEW ENGLAND REPRESENTATIVE FOR

DE LAVAL STEAM TURBINE COMPANY

Trenton, N. J.

All Well Waters —Should Be Chlorinated

The Elizabethtown Water Company, Elizabeth, New Jersey uses the new W & T Chlorinator, type M S P, to sterilize every drop of well water.

PUBLIC HEALTH ENGINEERS are rapidly dissipating the old-fashioned but popular idea that well waters are pure and safe to drink just because they are well waters and come from under-ground sources.

They know that well waters are liable to pollution—that a fissure in the rock or a break in the well casing often permits disease ladened contamination to enter the supposedly pure water—particularly in times of flood.

They know that hundreds of Typhoid Fever Epidemics have been caused by well waters.—They know that the three outstanding typhoid epidemics in recent history—Salem, Ohio — Lansing, Michigan — Santa Anna, California—were all caused by polluted, *unchlorinated* well water.

That is why there is a marked tendency toward the chlorination of all well waters—because a properly chlorinated water cannot cause disease—because chlorination will not change the physical or chemical characteristics of the water in any way — because chlorination costing but one cent per capita per year is the cheapest public health insurance.

"The Only Safe Water is a Sterilized Water"

WALLACE & TIERNAN

COMPANY, INCORPORATED

Manufacturers of Chlorine Control Apparatus

NEWARK , NEW JERSEY

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Founded 1853 Incorporated 1863

MERRIMAC CHEMICAL 1863 COMPANY

FILTER ALUM

Aluminum Sulphate

A basic, uniform product which has been used successfully by the leading water filtration plants in New England for many years.

Our location and shipping facilities place us in a position to offer insurpassable service and make us the logical source of supply for all filter plants in New England.

The aid and advice of our technical staff has often proved of great value to our customers. It is always at their service.

MERRIMAC CHEMICAL CO.

148 STATE ST., BOSTON, MASS.

Works:

EVERETT, MASS. WOBURN, MASS.

PRECALKED JOINT PIPE

Can be laid three times as fast as ordinary pipe, for half the labor. B. & S. type. Sand cast. Precalked Fittings also.

McWane Cast Iron Pipe Company

Eastern Office
819 Bankers Trust Bldg.
Philadelphia

Sales Representatives:
FRED A. HOUDLETTE & SON
40 Central Street, Boston
Eastern Mass., Me., N. H.

General Office and Foundry
BIRMINGHAM, ALA.

Main's Hotcoating for the inside of standpipes and water tanks, will stop all pitting and corroding, and is guaranteed for seven years.

Also

Main's Coverall Salt Air Paint, for the outside of standpipes and water tanks, guaranteed for four years.

M. B. MAIN **Box 189, Somers Point, N. J.**

GRIP PIPE FITTINGS

Connect without threading

As an Emergency Pipe Clamp

Before

After

Makes Possible an Immediate Repair. Saves Both Time and Money

MANUFACTURED BY

WARE COUPLING & NIPPLE CO.

WARE, MASS., U. S. A.

PRECALKED JOINT PIPE

Can be laid three times as fast as ordinary pipe, for half the labor. B. & S. type. Sand cast. Precalked Fittings also.

McWane Cast Iron Pipe Company

Eastern Office
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BIRMINGHAM, ALA.

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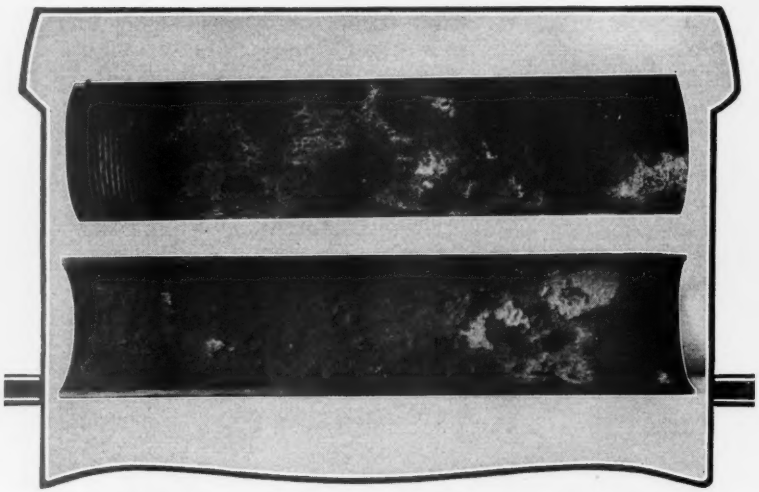


40 Years Old—Still Serving!

In the life of a pipe line, forty years is a long time — particularly if it is spent underground, subject within and without to corrosive onslaughts.

The pipe that can stand it is the pipe for service lines. That genuine wrought iron pipe has the necessary endurance is clearly demonstrated by service records all over the country of which the above photograph is an interesting example.

Here is a two-foot section from a line laid in 1886 by the Atchison Water Co. It is still good. It was removed simply to admit a valve. The line as a whole is in its 41st year of constant, uninterrupted service.

For sixty years, Byers has made pipe from genuine wrought iron. Its quality today is no less than that which has already defied rust for two, even three generations. Such, surely, is the ideal pipe for service lines.

A. M. BYERS COMPANY

Established 1864 **Pittsburgh, Pa.**

BYERS PIPE

GENUINE WROUGHT IRON

W. B. Hubbard & Sons Co.

FRANK W. HUBBARD, President-Treasurer
WALLACE R. HUBBARD, Assistant Treasurer

WATER WORKS SUPPLIES

176 Oliver Street, Boston, Mass.

PIERCE-PERRY CO.

SUCCESSORS TO
GEORGE E. GILCHRIST CO.

JOBBERS OF
Heating and Plumbing Supplies
Steel, Wrought Iron and Brass Pipe
Water Works Materials

DISTRIBUTORS OF
Hoffman Valves and Controlled Heat Equipment

236 Congress Street, Boston.

BOSTON PIPE & FITTINGS CO.

WHOLESALE JOBBERS

Byers Genuine Wrought Iron Pipe

National Pipe

COMPLETE LINE OF WATER WORKS SUPPLIES

273-279 CONGRESS ST., BOSTON

NOTICE:

Water-Works Contractors and Supply Houses!

Your card may be inserted here at a rate of $12 per year.

We Carry in BOSTON STOCK for Immediate Shipment

CAST IRON BELL AND SPIGOT
WATER PIPE AND FITTINGS
FLANGED PIPE in full and short lengths
WROUGHT PIPE

FRED A. HOUDLETTE & SON
(Incorporated)

40 Central Street, Boston, Mass.

Quotations furnished promptly for shipment from Foundry

CEMENT LINED SERVICE PIPE

With Specially Adapted Lead-lined Fittings

Also Curb Cocks which eliminate Iron to Brass Corrosion both inside and out.

CEMENT LINED PIPE CO.
LYNN, MASS.

SUMNER & DUNBAR

Manufacturers of and Dealers in
S. & G. Water Works Brass Goods
Byers' Wrought Iron Pipe
Service and Valve Boxes
Cast Iron Pipe and Fittings

12-18 Pittsburgh Street - - Boston, Mass.
Telephone, Liberty 1350

R. D. WOOD & CO.

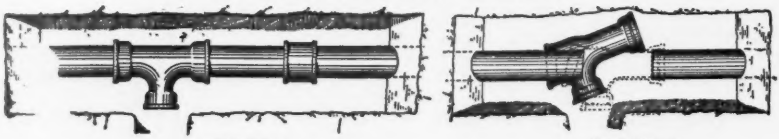
400 CHESTNUT STREET, PHILADELPHIA, PA.

Engineers, Iron Founders and Machinists

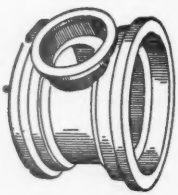
HYDRAULIC VALVES and MACHINERY

Cast Iron Pipe

CUTTING-IN TEES



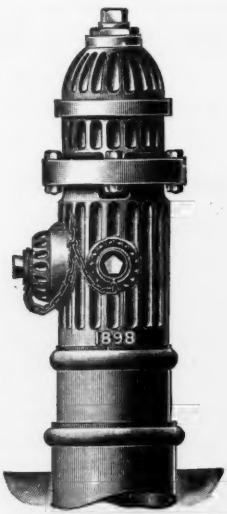
Old Way *Our Way*



Connections economically and easily made with one fitting. Saves sleeve, cuts, lead and unnecessary work and material.

"Reduced Specials"

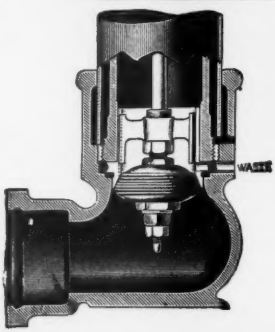
Cost of fittings reduced from 25% to 50%. Full strength. Deep bells. Convenient to handle. Sold by the piece.



Mathews Fire Hydrants

A half century of use has established their reputation as being the most economical, durable and simple hydrant.

Number in use exceeds total of all other makes combined.



Gate Valves

R. D. WOOD & CO. STANDARD
DOUBLE DISK
ANTI-FRICTION
EXTRA WEIGHT, FINISH
AND MATERIAL

KENNEDY

VALVES~PIPE FITTINGS~FIRE HYDRANTS

50th Anniversary 1877-1927

WATER supply and fire protection equipment *must* be thoroughly dependable. Only apparatus of the highest possible grade, meeting the most rigid requirements, can be used.

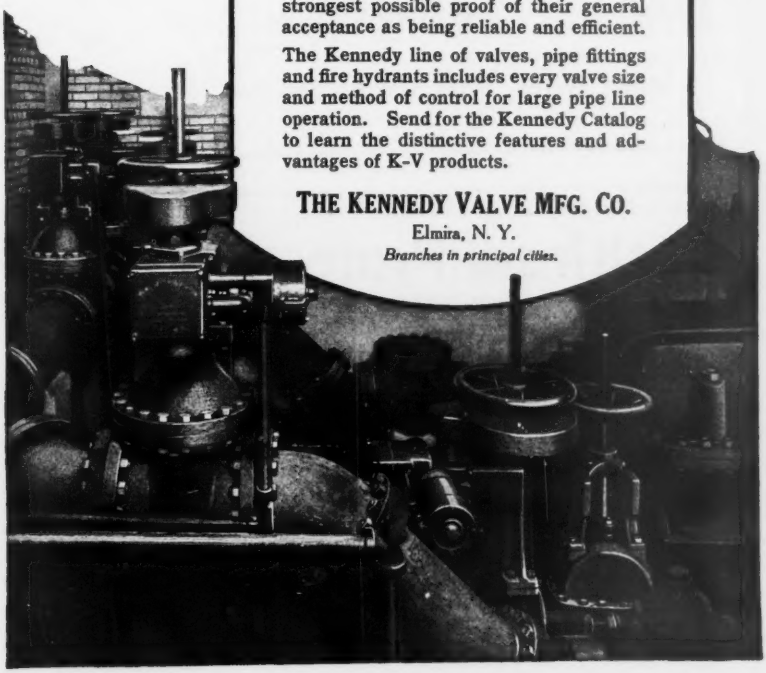
The wide use of Kennedy Valves and Fire Hydrants by villages, towns and cities throughout the country is therefore the strongest possible proof of their general acceptance as being reliable and efficient.

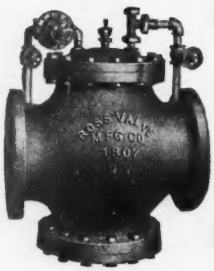
The Kennedy line of valves, pipe fittings and fire hydrants includes every valve size and method of control for large pipe line operation. Send for the Kennedy Catalog to learn the distinctive features and advantages of K-V products.

THE KENNEDY VALVE MFG. CO.

Elmira, N. Y.

Branches in principal cities.





Automatic Pressure Control Valves
Feed Water Filters
Portable Fire Hydrant Heads
Hydraulic Engines
Hydraulic Booster Pumps

ROSS VALVE MFG. CO., INC. **TROY, N. Y.**
ESTABLISHED 1879

Coffin Valve Co.

NEPONSET, MASS.

Sluice Gates, Gate Valves and Fire Hydrants

Health and Protection First

Water delivered through dirty pipes
may be a MENACE.

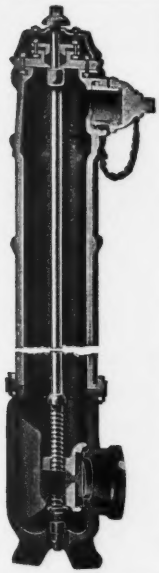
Incrusted water pipes mean inefficiency
and loss of Fire Protection.

We Guarantee the Results of Our
Method of Cleaning.

WRITE US.

National Water Main Cleaning Co.

50 Church Street **New York City**



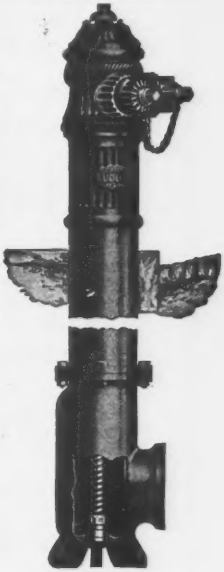
LUDLOW VALVE MFG. CO.

MANUFACTURERS OF

VALVES and FIRE HYDRANTS

This hydrant is anti-freezing, because when the drainage is good no water is left in it to freeze.

The drip is directly in the bottom of the hydrant and drains perfectly. It is protected by its valve, which never leaves its socket and cannot be clogged.



DOUBLE AND SINGLE GATE VALVES, ALSO CHECK VALVES, FOOT VALVES.

FIRE HYDRANTS.

YARD, WASH, AND FLUSH HYDRANTS.

☞ SEND FOR CIRCULARS ☜

OFFICE AND WORKS: FOOT OF ADAMS STREET, TROY, N. Y.

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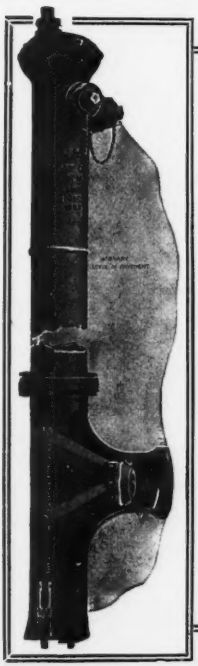
62 GOLD ST.	HARRISON BLDG.	1112 TREMONT BLDG.	1ST NAT. BANK BLDG.	THE ROOKERY	R. A. LONG BLDG.



The Knuckle Joint Principle in Genuine "Rensselaer" Improved "Corey" Fire Hydrants—Means Ease of Operation

BECAUSE this principle gives great power to open or close the gate just when it is needed, and speed in movement when power is unnecessary.

The first turn of the spindle, when the gate is open, moves the valve nearly two inches, after which the speed decreases and power throughout the knuckle joint increases, until at the time of closing the valve moves scarcely one-sixteenth of an inch at each turn of the spindle, eliminating danger from water hammer when closing hydrant.

The gate is closed very tight with slight application of power to the wrench by the operator. The drip valve in the Corey Fire Hydrant prevents freezing. No accident or damage to property can occur with this hydrant by flooding the streets where runaway teams or other accident breaks off or otherwise injures the hydrant standpipe, if hydrant was properly closed at time of accident.

It will be readily seen that the hydrant gate is held in position when shut by the four arms forming braces between the back of the hydrant and the seat, consequently the hydrant barrel can be broken completely off above the ground, but the valves remain tight.

Write for copy of our Hydrant Book No. 9.

CHARLES L. BROWN,
New England Sales Manager, Lock Box 2, Northboro, Mass.

RENSSELAER VALVE COMPANY
TROY, N. Y.

THE CHAPMAN VALVE MANUFACTURING COMPANY

Manufacturers of

Gate Valves Drip Valves

Gate Fire Hydrants

Corporation Cocks Curb Cocks

Anderson Couplings

Lead Pipe Connections

Trade

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Indian Orchard, Mass.

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141 High St.	180 Lafayette St.	1011 Filbert St.	116 N. Jefferson St.

Type of Eddy Hydrant Popularly Used

More Than Sixty Years of Experience Goes Into All

EDDY

Hydrants and Valves

BUILT TO MEET EVERY EXACTING REQUIREMENT OF WATER-WORKS SERVICE

Practical water-works men instantly recognize the superior features of Eddy products. For instance, with the hydrant.

A damaged valve can be replaced in a few minutes — Water hammer is avoided by the valve closing against the pressure and the use of the cut-off under the valve, which gradually closes it —
Stems cannot be bent in closing the hydrant.
Nothing can lodge on the valve seat to prevent closing of the valve —
The Drip Rod can be removed without interfering with the hydrant in any manner —
The position of the stem of the hydrant indicates accurately the position of the valve —
Whatever can pass the valve opening will pass the standpipe —
No frost case necessary —
All of these points are explained thoroughly in our catalogue, which will pay you to study.

The Eddy Valve, Too

Has its distinctive and individual features. The double disk gates are free to adjust themselves in different positions every time the valve is closed, thereby keeping smooth and tight faces. And two bronze hooks on the ball loosely engage with the gates to prevent them from spreading at the top. The center bearing gates are forced to their seats with equal pressure at all points. There is a good deal more worth knowing about Eddy Valves. Further details will be sent for the asking.

Other Eddy Products

The Eddy line of water-works products also includes horizontal and vertical check valves, foot valves, hydraulically operated valves, indicator posts, etc.
All goods made by the Eddy Valve Company are manufactured exclusively at Waterford, New York.

WRITE FOR CATALOGUE

EDDY VALVE COMPANY

WATERFORD, N. Y., U. S. A.

EMAUS PIPE FOUNDRY,
DONALDSON IRON CO.,

MANUFACTURERS
...OF...

CAST IRON PIPE

...AND...

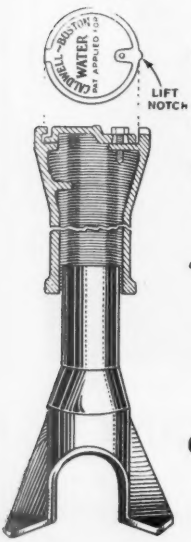
Special Castings for Water and Gas.
Also Flange Pipe, Street Castings,
Manhole Heads and Covers, etc.

EMAUS,
LEHIGH COUNTY, PA.

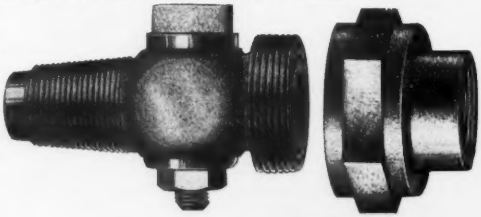
J. G. EBERLEIN, President and Treasurer.
J. M. GILBERT, Secretary.

The "BEST" Cast Iron Curb Box

Top section is interchangeable with the "Slide Type" Buffalo Box



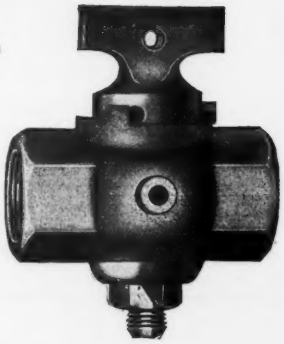
No change necessary in wrench or shut off keys

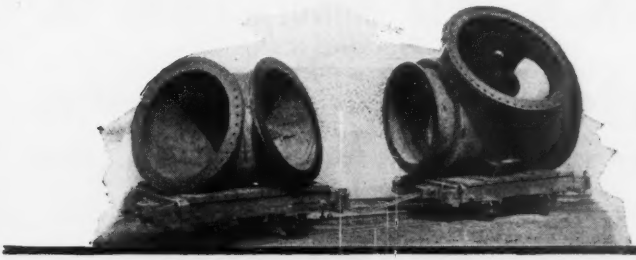


"CALDWELL" Water Works
Brass Goods, Curb and
Valve Boxes

None better and few as good

GEORGE A. CALDWELL CO.
Mattapan Square
BOSTON, MASS.





Large standard fittings and special castings

In our various plants we have unusual facilities for handling the largest standard fittings and for making especially heavy castings.

WHILE standard connections should be adopted as far as possible, it sometimes happens that an exception has to be made to meet unusual conditions. When such conditions arise communicate with our nearest sales office. Our equipment is so complete that oftentimes the castings can be designed to fit equipment already available at one of our plants. This saves the cost and lessens delivery time.

United States Cast Iron Pipe and Foundry Company

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Philadelphia *New York*
Chicago *San Francisco*
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Buffalo *Dallas*
Cleveland *Kansas City*
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THE A. P. SMITH MANUFACTURING CO.

EAST ORANGE, N. J.

Manufacturers of

Tapping Machines, Fire Hydrants, Water Gates,
Economic Lead Furnaces,
Corporation and Curb Cocks, Brass and Aluminum Castings.
Also General Supplies for Water and Gas Works.

Write for Catalogue.

NICHOLAS ENGEL

JOHN FOX & CO.

CAST IRON
WATER & GAS PIPES
FLANGE PIPE

Special Castings, Fire Hydrants, Valves
General Foundry and Machine Work
WOOLWORTH BUILDING 233 BROADWAY
NEW YORK CITY

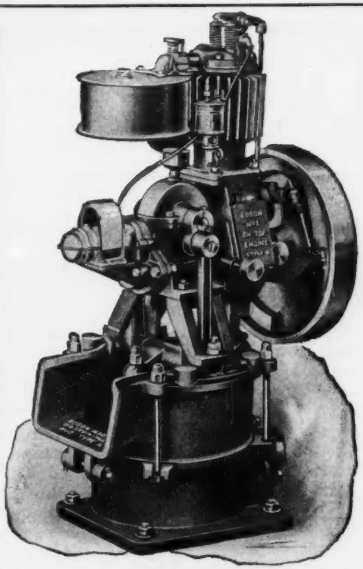
HIGHEST AWARD, GOLD MEDAL,
ST. LOUIS EXPOSITION, 1904

Over 100 Water Departments
use
LEAD-LINED IRON and TIN-LINED PIPES
for their service connections

MANUFACTURED BY

Lead Lined Iron Pipe Company

Wakefield Mass.



STYLE "B" ENGINE – STYLE "A" NO. 3 PUMP
Furnished on Hand Skid or 4-wheel Truck

"On Top" Trench Pump Unit

EDSON

DIAPHRAGM
PUMP SPECIALTIES

Hand and Power Outfits

Try one of our Gasoline Two-Pump
EMERGENCY UNITS

Insist on GENUINE EDSON Pumps,
Suction Hose, Diaphragm
with Bead, etc.

New Catalogue on application

Edson Manufacturing Corp.
375 Broadway Boston, Mass.

Warren Foundry and Pipe Co.

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SALES OFFICES
11 BROADWAY, NEW YORK
201 DEVONSHIRE ST., BOSTON, MASS.
Telephone, Fort Hill 5951

CAST IRON PIPE

Bell and Spigot Flanged Pipe
Special Castings
Flexible Joint Pipe Cylinders

Water Gas Sewers Culverts

Works, Phillipsburg, N. J.

LARGE STOCK ENABLES US TO MAKE QUICK SHIPMENTS

TRADE **"LEADITE"** MARK

Registered U. S. Pat. Office

Only 51 days between the decision to build an emergency water works plant - - *and the finished job!*

- - the speed with which Leadite jointing can be accomplished contributed to this remarkable feat.

THE line illustrated here is 26,000 ft. of 12″ pipe with LEADITE joints.

Owing to the emergency which arose in the city for which the installation was made no trenching could be attempted.

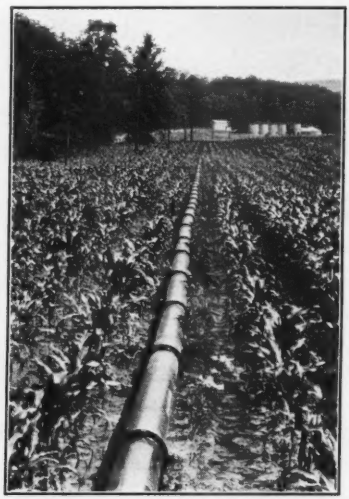
The line lies throughout its entire length on the surface of the ground without any bracing except at the bends.

After completion the line was tested to 260 lbs. pump pressure.

It is now under constant pump working pressure of 230 lbs. For over 30 years now, LEADITE has demonstrated by test and experience that it is absolutely permanent and secure.

Leadite is self-caulking and is so simple to use that the method of using it can be taught to even the most inexperienced help in a very short time.

Added to its speed and ease of use — Leadite saves at least 75% on account of saving in material and labor.



Part of the 26,000 ft. installation, crossing an open field. Chas. E. Waddell & Co., Engineers.

Specify and use LEADITE —it saves at least 75%

Be sure it is LEADITE and accept no imitations : :

The pioneer self-caulking material for c. i. pipe. Tested and used for over 30 years.

THE LEADITE COMPANY Land Title Bldg. PHILADELPHIA, PA.

NO CAULKING

Chadwick-Boston Lead Co.

800 Albany St., Boston

Agents for

The Celebrated "ULCO"

LEAD WOOL

(Every Atom Pure Lead)

For calking pipe joints under the most difficult conditions.

For overhead joints, or in wet places where the use of molten lead is not only impracticable but dangerous — **LEAD WOOL** may be used to advantage.

It makes an absolutely tight joint which will withstand the highest pressure, yet be sufficiently elastic to allow considerable sagging or settling of the pipe without danger of a leak.

As compared with the poured joint, in this respect, the superiority of **LEAD WOOL** is apparent.

Manufacturers of

Lead Pipe, Tin Lined Lead Pipe, Pure Block-Tin Pipe, Solder, White Lead and Red Lead.

HIGHEST QUALITY SOFT BRANDS

PIG LEAD

TEN CENTS PER POUND PRICE TEN CENTS PER POUND PRICE TEN CENTS PER POUND TEN CENTS

Join Your Water Mains

WITH

LEAD-HYDRO-TITE

TRADEMARK

AND CUT YOUR EXPENSES

50% FIRST COST

50% SMALLER BELL HOLES

75% HANDLING

100% CALKING

OUR PROPOSAL

That the prospective users purchase a trial lot of 1 to 5 bags, and that this be used under the direction and according to the instructions of our representative.

If, after a trial, the purchaser is not satisfied with the material, any surplus not used to be returned to the Hydraulic Development Company, and no charge to be made for any of the Hydro-Tite furnished.

Owned, Manufactured and Sold by New Englanders

Write for Particulars

Hydraulic Development Company

296 BOYLSTON ST., BOSTON, MASS.

50 Church Street
New York City

7 South Dearborn Street
Chicago, Illinois

TEN CENTS PER POUND PRICE TEN CENTS PER POUND PRICE TEN CENTS PER POUND TEN CENTS

"The Goods That Please"

Corporation and Curb Cocks

We have them to meet every requirement

ORIGINAL

"Hays-Erie"

Extension Service Boxes of proven advantages

Let us send at our risk, on 30 days' trial, a

Payne's Patent Tapping Machine

which is recognized to be the most easily operated owing to the few working parts.

Hays Mfg. Co., ERIE PENNSYLVANIA

Established 1869

New!
SERVICE BOXES
With *Stay-on* Covers
Just what you have been waiting for . . . Interchangeable with "Buffalo" boxes . . .
Ask for Monitor Service Box catalog.

THE CAST IRON PIPE THAT MAKES ITS OWN JOINTS

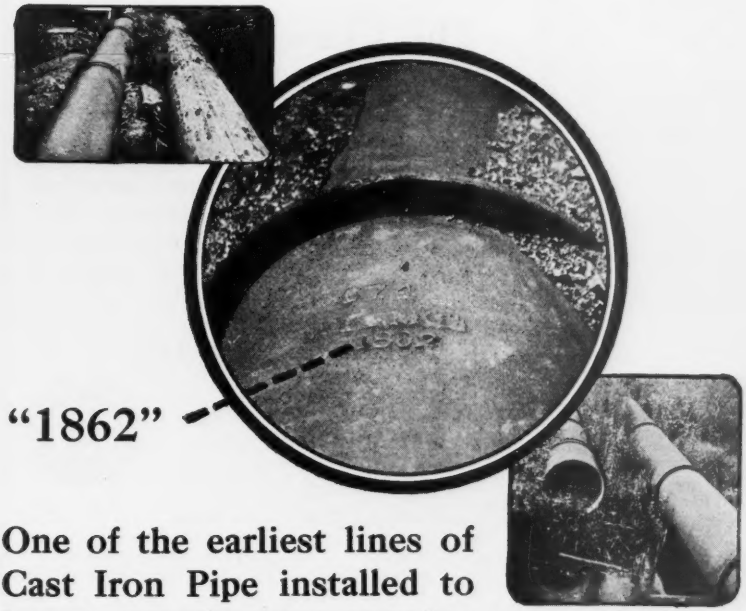
East Jaffrey, N. H.

Here's dependable water supply for you!

Dependable because it's 100% cast iron. No hot lead, no cold lead, no lead substitutes, no pouring, no calking. Nothing to work loose, nothing to deteriorate in these flexible, dependable joints—machined iron-to-iron *joints as tight as the wall of the pipe itself.*

Wrenches the only tools. Address nearest office.

UNIVERSAL CAST IRON PIPE
No bell holes to dig: No joints to calk
THE CENTRAL FOUNDRY COMPANY
Subsidiary of The Universal Pipe and Radiator Company
Graybar Building, 420 Lexington Avenue
New York



One of the earliest lines of Cast Iron Pipe installed to insure continuous service

This line runs across salt marshes. It demonstrates the high resistance of Cast Iron Pipe to corrosion.

After sixty-five years under these conditions, the line shows not the slightest sign of weakness anywhere.

Write for U. S. Cast Iron Pipe handbook. It contains necessary data for construction engineers.

United States Cast Iron Pipe and Foundry Company

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Burlington, New Jersey

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Chicago
Birmingham
Buffalo
Cleveland
New York
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Pittsburgh
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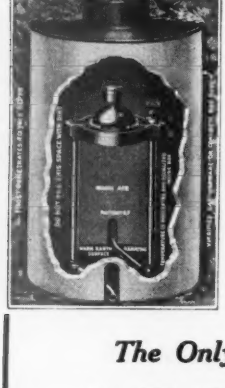


The Clark Meter Box

affords absolute protection from damage of any nature.

Perfect Lock

consists of one-piece phosphor bronze bolt engaging on an incline plane on cover to lock and likewise engages on a similar plane on lid to unlock. No rivets, bolts or screws, to rust, preventing operation.

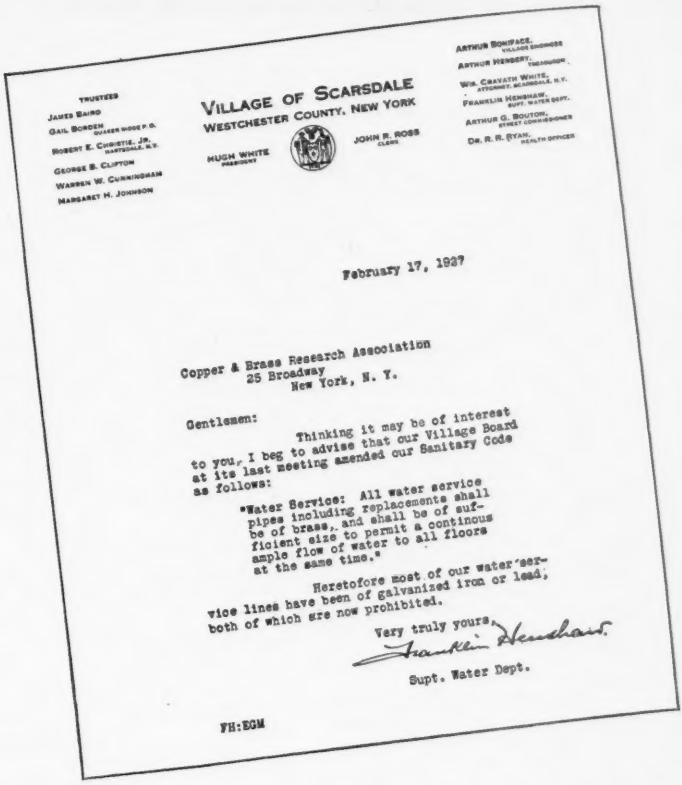
The Only All Bronze Meter Box Lock.

H. W. CLARK COMPANY

Manufacturers Waterworks Equipment

MATTOON, ILLINOIS

Meter Boxes	Meter Coupling Yokes	Valve Boxes
Vitrified Box Bodies	Service Boxes	Valve Housings
Forms for Concrete Bodies	Repair Lids	Meter Testing Machines
Meter Couplings	Vise for Brass Pipe	Trouble Finding Instruments



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FRANKLIN HENSHAW, SUPT. WATER DEPT.
ARTHUR G. BOUTON, STREET COMMISSIONER
DR. R. H. RYAN, HEALTH OFFICER

February 17, 1927

Copper & Brass Research Association
25 Broadway
New York, N. Y.

Gentlemen:

Thinking it may be of interest to you, I beg to advise that our Village Board at its last meeting amended our Sanitary Code as follows:

"Water Service: All water service pipes including replacements shall be of brass, and shall be of sufficient size to permit a continous ample flow of water to all floors at the same time."

Heretofore most of our water service lines have been of galvanized iron or lead, both of which are now prohibited.

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